THE

TROPICAL

CROPS

OTIS WARREN BARRETT

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THE TROPICAL CROPS

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O. W. Barrett.

PLATE I.—A planter's residence in Porto Rico. The royal palms give it poise; it overlooks the fields and orchards; the collection of rare fruits, beginning at the right, gives it a dignified distinction.

THE TROPICAL CROPS

A popular treatment of the practice of agriculture in tropical regions, with discussion of cropping systems and methods of growing the leading products

BY

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TO MY WIFE

WHO FOR THIRTY YEARS HAS SHARED MY TROPICAL EXPERIENCES AND, IN MANY CASES, HAS BEEN THE *DEA EX MACHINA* MAKING POSSIBLE THE GAINING OF FACTS AND THE GRASPING OF THE SPIRIT OF THINGS TROPICAL.

PREFACE

Forty per cent of the earth's surface is in the tropics. This zone has for the last 3,000 years been of great importance to the progress of the human race and will eventually contribute very largely to the support of the greater portion of the world's peoples.

The major crops of the tropics have expanded until even now they supply a very prominent part of the international trade in foodstuffs, fibers, and industrial oil materials. But with all this important share in the world's commerce, there goes a very unfortunate general lack of knowledge regarding the ways and means of procuring these raw materials. The public is rapidly becoming interested in this zone. Excursions into the New World tropics, especially, and the facilities of modern travel therein have done much in the last decade to advertise this great region to Americans.

Capital is pouring in, millions of it. Prospective investors need to appreciate the present status and the outlook of every enterprise depending on tropical agriculture. The merchant and industrialist no longer are content to overlook the alinement and the perspective of each of the commodities passing through their hands; they need and in most cases desire a clear picture of copra in the making, of abacá and sisal, of the spices, oils, starches, as they start on the trade routes from plantation to the public's end—the markets. The rubber field superintendent wants to know how the oil palm and cassava affect his work. The success of a "key" crop in a certain locality predicates the possible production of several companion or accessory crops there.

Technical treatises there are for specialists in the various lines of work, but the available accurate information, pre-

sented in readable and comprehensible form for the average individual interested in getting the precise correlation of data concerning the basic factors in great tropical enterprises and the commodities upon which they depend, is not sufficiently in evidence.

The tropical crop producers and crop handlers are broadening their vision rapidly; the utilization of wastes, and the by-product business affect the raw-material industries at an increasing rate; experts in special lines nowadays desire to know the actual status and the trend of those items that affect more or less directly their own fields.

Authoritative data, condensed but not didactic, are not easy to find; but they are greatly needed in the sugar-cane plantation, the tea garden, the citrus orchard. These products of the so-called torrid (but really temperate) zone and their procurement possess certain features, empirical or presumptive, which are distinctly positive while others, evidenced by conflicting opinions and unexplained phenomena, appear negative; both kinds are interesting to the consumer as well as the producer.

In presenting the data regarding the world's principal tropical crops, the author has had two purposes constantly in mind. In the first place, an effort has been made to confine the treatment of the subject material very largely to first-hand observed information, in the conviction that hearsay ideas and evidence are always liable to more or less distortion through long-distance transmission and misunderstandings. And in the second place, there has been an earnest purpose to present the pictures of these things in such a way that the reader can see them in their true relationships and thus accord them the respectful mental attitude which thirty years of practical experience has developed in the author's judgment.

O. W. Barrett.

San Juan, Porto Rico,
April 18, 1928.

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THE TROPICAL CROPS

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CHAPTER I

TROPICAL FIELD PRACTICES AND CONDITIONS

THE crop systems in the tropics are influenced primarily by the climate, which, instead of an eight- or nine-months crop season, is of twelve months duration. The weather is not hotter, generally speaking, but it is less changeable and usually has no "waste period."

The main factors to consider in the discussion of tropical crop systems, however, may be grouped under soil, water, air, crops, and fertilizers. As a general rule there is more breadth and depth to the subject of crop systems in the tropics than in the temperate zones; the extremes of cultural practices are interesting, but often difficult of satisfactory explanation. Three examples may suffice as illustrations.

1. The paddy (padi), or rice, fields of central Luzon have been planted for centuries, either with no rotation whatever or with sweet potatoes and cotton. The fields lie fallow for seven or eight months, then the water is turned on, the resultant mud with its tangle of weeds is stirred up thoroughly, not to say plowed, the weeds and grass are allowed to decay in the mud, then the rice seedlings are set into the oozy surface; in three or four months the palay, or rice heads, are harvested.

2. In the neo-tropics many tribes have long been accustomed to the following practice: A small area in the jungle, usually near a river or lake, is kept cleared, at least for a number of years; in this clearing a dozen or two families maintain a rotation of cassava, bananas, maize, beans, and

sweet potatoes. Instead of keeping domesticated animals, the meat supply is obtained with the blow-gun, or traps (very ingenious and of many types for bird, beast, and fish), or arrows (for fish). Wild fruits and roots and also insects round out the mênu. This primitive system stands as one of the simplest and best in the world.

3. The "clearing" system so common throughout Africa and the Far East reaches its climax in the Congo where the following excellent practice is prevalent: An area of jungle, suited to the size of the village, is felled and so far as convenient burned, the larger remaining logs being left to decay, and some trees, too hard for the hatchets and knives, girdled and left standing. Maize is first planted, with a catch-crop of rice, the latter coming off in about three months and the maize one or two months later. As soon as the rice is out cassava is put in among the hills of maize and by the end of the first year the cassava is about ready to harvest. Rotation of these and perhaps one or two other crops fills the second and third years so that few weeds can come in; in the third year plantains and bananas are set fairly close among the other crops; and from the fourth to the seventh or eighth year the area is a solid banana plantation. By exchanging crop materials, or by running two or three smaller "vookas" or clearings, a year or two apart, such a primitive Bantu community solves the food problem very simply, cheaply, and effectively.

August Chevalier has classified the crop systems of the world.[1] He recognizes some twenty-four ecological types of food-plant and animal production; most of these, of course, are tropical.

The average untraveled economist is prone to consider North American and European crop systems as the only ones worthy of thought. As Chevalier states, there are numerous regions wherein human societies have for ages maintained successful systems totally different from these.

[1] Chevalier, Aug. Intern. Institute of Agriculture, New Series, Vol. III, No. 3, 1925.

Agriculture walks best on two legs—domesticated plants and animals—but it can get along with either one. The prime object of agriculture is to provide mankind with sustenance, vegetable or animal or both; and the systems of securing food, clothing, and shelter must vary according to the four great factors: topography, climate, local vegetation, and status of the people.

The Masai of Tanganyika and the Baguirmi of the waterless Sudan wastes graze their cattle and browse their camels, drink their blood and milk and eat their meat; and that is best for them. The Mois of Cambodia, contrariwise, grow their floating rice in lakes and raise fish and ducks, feeding them special sorts of aquatic plants which they have bred up for just that system of agriculture, living comfortably without contact with the soil.

Whether agricultural systems were instituted in southern Asia, in the Sudan, or in Peru is a debatable question not for these pages. Some 40,000 or more years ago savage inhabitants of the temperate zone struggled (and often failed) against the winters and finally learned to store plant and animal food materials from one growing season to the next. The tropical climate once extended far beyond its present limits. The great feature in paleo-agriculture was the full year—thirteen moons without the devastating winter period.

Agriology, the comparative study of mankind's modes of living before the civilized epoch, is one of the most interesting yet most difficult of the natural sciences. Scarcity of food was the prevailing exigency, which our forebears always fought—not always with success.

SOIL

In the primitive systems the soil was left much to itself. After felling and burning the trees, the planting holes, when necessary, were made with a sharpened stake, as still in many countries. The hoe was a great invention; it could kill weeds and move earth around a plant, two prime cultural

factors. Some five or six thousand years ago semi-civilized agronomists learned how to save crop plants from drought. Irrigation, drainage, and finally aeration have been studied fairly thoroughly, but the end is not yet reached.

In the past few decades modern tilth practices—plowing, harrowing, cultivating—have come to be applied to sugar-cane, almost as a matter of necessity, and in a measure to some of the cotton fields. Whereas a generation or so ago the cane field was turned over with a heavy single-furrow plow drawn by three to ten yoke of oxen or bulls, nowadays a brisk little tractor drags two or three deep-cutting discs at about five times the speed of the ox outfit. Incidentally, the modern tractor idea may be carried too far. An inexperienced superintendent may put a heavy tractor on an old sugar-cane field, which had never seen any but shallow plowing, and may ruin the field at once by turning sterile earth and hardpan on top.

Really proper tilth in tropical crop areas is rare. The great crops of coffee, tea, cacao, coconuts, rubber, sesame seldom see a plow; a few hundred thousand acres of bananas, citrus fruits, pineapples, tobacco are plowed, but they do not run into so many millions as do the others.

Much of the tilled land of both tropics, outside of the great river valleys, is red clay; and this can be plowed only when the moisture-content is just right, neither hard-caked nor pasty. Sandy soils do not plow well.

Dynamite may be used to loosen hard-packed soil or hardpan; small charges placed 3 or 4 feet deep are best. Stumps may also be handled with explosives, even drains dug.

Aeration is more important than is generally believed. The vertical forking method described in the chapter on cacao is applicable to rubber, fruit, coconuts, tea, and coffee.

The micro-organic population of tropical soils is very similar, as to types at least, to those of the temperate zones. The protozoa and bacteria are about the same but there

are more fungi and algæ, as would be expected when there is no stopping and (when the rainfall is even) no great fluctuation of the activity of these unseen inhabitants throughout the year.[1] Some day it may be known just what these algæ and fungi are doing in the soil. If some time, in some measure, the behavior and the interactions of these bacteria and protozoa can be controlled, fortunes will be made with crops as easily as an engineer turns on or off a flood of water.

Twenty-five years ago the execrable test-tube theory discolored the conception of soil fertility: it went into the discard. Until quite recently it was held that a film of "soil water" surrounded each mineral particle in the soil; now it is learned that plants would soon disappear were it not that a colloidal film, containing complex compounds, envelops the mineral particles and retains the moisture which otherwise would be too unstable for root-hairs to manage.

Another new idea to which the tropical planter is accustoming himself is the automatic balancing of the micro-organic soil population. He grows sugar-cane in a certain field for 300 years; but if he tries it with tobacco, cotton, or jute, without rotation, he finds that the soil is "tired." Now it is learned that if the soil is properly tilled—aerated, drained, and watered—there will be little or no auto-intoxication, because then the whole micro-organismic faunæ and floræ can "balance," the surplus of any organic substance being promptly turned into nitrates, carbon dioxide, and water, to be utilized partially by the roots but largely lost in the downward seepage. Competition is severe, tragically so, just beneath the soil surface. Very fortunately for the tropical farmer there are many castes and customs among the microscopic animals and plants; it is a dark world there, and it will require a century to explore and understand all

[1] The mass of micro-organisms in an acre of average soil is estimated at 500 to 700 pounds. A gram of surface earth contains from few to many million specimens.

these associations which stand between him and the Mineral Kingdom.

WATER

Drainage.

With the very heavy rainfall of many tropical countries, drainage is a serious problem. Ditches and canals are expensive and they soon choke with weeds and vines. Especially in the Malayan coastal lands some excellent practices have been adopted whereby coconuts, betel, rubber, and the like can be grown in the rich soils of swampy districts near the sea.

Under-drainage is coming into practice. Subsoil tile drains are especially valuable in some sugar-cane districts. Much land now regarded as too cold and sour for crops could be put in good condition by porous tiles laid deep enough to be out of the way of plows. "Gopher" plows for making "mole drains" have come into use; these subterranean burrows last for two years or more and remove the surplus water from "too heavy" land. Since the colloids hold the moisture above, the feeding zone of the roots may be deepened.

Mulching.

In the chapter on rubber it is pointed out that bare soil in the tropics is dangerous. Much has been written on the theory and practice of mulching; and there is room for experimental work on all lines of this subject—chemical, bacteriological, physical. Much depends on the roots getting the maximum benefit from their environment: a crack in the soil upsets their work; over-heating the surface causes several sorts of troubles; weeds steal and grasses poison the earth and the soil-soup, the solution of organic and inorganic substances surrounding the soil particles without which a plant cannot live.

Mulching is not a simple practice. In fact, there are three very distinct kinds of mulch, if the common idea is

accepted that a blanket of living plants is a "live mulch" and not a low cover-crop.

The dust mulch is of great value in dry periods, in heavy soils. When the rainfall is dangerously light, as much of the soil-moisture must be conserved as possible. In the large cotton fields in Haiti the writer has seen a mule-drawn cultivator perfecting the foot-deep dust mulch which kept three-foot cotton plants thrifty and fresh with not even a good dew for weeks. An acre of bare soil ordinarily loses in full sunlight in a day about 6 tons of water; keeping a dust mulch on the surface reduces the loss to about 4½ tons.

The cracking of clayey soil is more serious than generally believed. Breaking the delicate rootlets is bad, but these cracks (2 or 3 inches wide sometimes) act like chimneys, pulling out the moisture from the deeper layers of the soil. If the mouths of these yawning fissures can be filled with loose surface earth—dust—half the trouble is stopped.

Rubber, cacao, coffee, and tea enjoy a leaf mulch. Cane trash, if a sugar plantation is within hauling distance, rice straw, or fresh-cut jungle brush serve well enough. Only a light layer should be applied, in order not to call the roots to the surface.

Live mulches require continual attention. The ideal sort should form a loose mat not too close to the soil, should not climb on the crop plants, should spread easily and last a half year at least. If the live mulch produces food or fodder, so much the better, as, for example, the cowpea.

Water reservoirs.

Wherever there is danger of crops suffering from drought, the tropical planter should provide some form of water supply. When regular irrigation cannot be secured, there should be some sort of tank, or reservoir, large enough to be of real value during a long dry period. This water storage should be constructed in such a position that piping or

ditches can be run to the most advantageous parts of the estate; a windmill pump can be used to raise part of the supply to a level higher than the reservoir. Generally a hydraulic ram or windmill pump suffices for filling the tank, in the rainy season, from some nearby water-course. In some cases a gasoline motor or windmill will lift the supply from a well. In very dry regions great care must be exercised to avoid injury from salt in the water.

Catchment areas, more or less sloping if possible, are amazingly efficient in collecting rain-water. The pavement should be concrete if permanence and cleanness are desired, but brick, tile, paving stone, mortared gravel, or even a thick floor of clay will suffice. A few thousand square feet in even a light rain may turn into the reservoir an immense volume of water: a ¼-inch rain on a catchment floor 50 by 100 feet turns over 100 cubic feet, or, say, 3⅛ tons, or 25 barrels into the cistern. The reservoir should, of course, be tightly covered to avoid evaporation, mosquitoes, and contamination. Two or three good rains on a generous catchment floor furnish enough water to supply the family, stables, gardens, lawns, orchards, and valuable plants through a long dry season, at least.

In localities in which droughts are expected, the roofs of all the main buildings should be furnished with gutters, solidly affixed and kept in repair, leading into one or more substantial cisterns. If gutters and inlets are properly made, no leaves nor vermin can get in, and the water will keep clear and safe for human consumption for a year. In India and Ceylon, existence would be precarious in many districts without the very numerous "tanks," as the British residents call these earth-walled reservoirs. The system dates from long before the British engineers ever heard of India.

AIR

Soil aeration.

Aeration of heavy soils is a difficult practice. Many clays when saturated are practically air-tight; roots require air,

air movement, and drown in a few days if they cannot get it. Over many large areas in most tropical countries the clayey subsoil is so near the surface that, even with drains, the rainy months put a severe strain on crops like cacao, coffee, and coconuts. In Chapter V a method for letting air into the heavy soils is described. Forking is seldom necessary and always breaks many roots, though but few may appear on the surface.

To "sweeten" heavy soil in some districts in India narrow beds or walls of the earth are made as high as possible, and through some obscure nitrification process, perhaps, the hot sun during the dry season bakes the soil—changes its microflora; when these beds are again leveled the crop can go in safely. The rab system stresses firing, or burning over the entire soil surface between crop seasons.

Windbreaks.

Windbelts are far too rare in the tropics. Any wind movement of over fifteen miles an hour is injurious, mechanically, to plants. Cacao, citrus fruits, and vanilla are particularly sensitive to wind-whipping; a few hours of threshing in strong gusts of wind, and the delicate "flushes" of leaves at the tips of branches are torn and ruined.

For temporary purposes and for low-growing crops, serviceable belts are best made of tephrosia (*Tephrosia candida*) or pigeon pea (Cajanus). These shrubs grow rapidly, may be planted as a dense hedge, pruned if necessary, and reach a height of 8 to 12 feet, the cajan, or pigeon pea, being the taller. If the field or plat is much exposed or if the winds are strong, these belts may be planted every hundred feet or so, at right-angles to the prevailing wind.

For orchards some strong quick-growing leguminous tree should be set across the prevailing wind in rows thick enough to stop practically all wind movement. For the smaller fruit-trees, coffee, cacao, and the like, there is perhaps no better species than the madre de cacao (*Gliricidia sepium*) of tropical America. This possesses many good

points: it propagates by stake-cuttings; it grows rapidly, reaching a height of 15 to 30 feet in a few years; the young wood is soft, while that of the old trunks is quite hard; it stands pruning, the branches, leaves and explosive pods forming a rich mulch; it lives for twenty years or so.

The malay-apple (*Eugenia* or *Jambos malaccensis*), or ohia, is also recommended. While not a legume, it has many advantages over most species: it forms a denser belt than the gliricidia, grows quickly, and produces edible fruit; the very dark leaves and the magnificent flowers are ornamental; the scarlet fruit, the size of a small pear, is greedily eaten by poultry. Propagation is by seed only. This tree usually stands 20 to 40 feet high.

Caro (*Enterolobium cyclocarpum*) is a rapid-growing leguminous tree of tropical America; it stands 20 to 50 feet high, but is not very compact. Its broad spirally curved pods are feed for cattle.

Mangos are frequently used for a tall permanent windbelt. They endure any amount of severe pruning, live for generations, bear edible fruit, seldom suffer from the strongest winds, and may stand 60 feet or more. They are tremendous feeders, however, and no other tree will succeed near them unless a deep trench is dug to cut the roots on the orchard side.

Bamboos are frequently planted about orchards in both tropics. They grow rapidly and very well,—60 feet; but a narrow trench 4 or 5 feet deep must be made to keep their roots from robbing and apparently poisoning the other plants. Bamboo leaves, instead of being a good mulch, seem to contain some poisonous substance, a solution of which is harmful to the higher plants.

Holding the soil.

In many windy regions are areas of light soil which, if not anchored, may be moved by the wind. Any plant that strikes root deeply and hold on during the dry weather will

protect the soil from blowing. If near the sea-coast most plants are injured by the spindrift; casuarina and majagua (*Hibiscus tiliaceus*), however, may be used on the sea-beach. Most of the leguminous vines rapidly cover a wind-swept place. Castor-bean, pigeon pea, *Leucœna glauca,* and several other species give good results.

Soil erosion is another negative factor in tropical farming. Not only the loss of the rich layer ("flor de la tierra," in Antillean Spanish) of surface earth, but also the gullying, or channeling, of the soil to a dangerous depth is caused by heavy rains on unprotected more or less sloping land. When the slope is slight, an ordinary cover-crop is generally sufficient to hold the surface layer intact; cowpea, velvet or Lyon bean, canvalia, asparagus pea, yam bean are the best.

On land with a considerable slope, either terracing or cross-trenching or both may be necessary. Terraces are expensive but usually very efficient. In the Mountain Province of the Philippines steep slopes are covered with stone-faced terraces for the paddy, or irrigated rice fields. Some of these have a width less than the height of the nearly vertical wall. Nevertheless, these narrow fields, arranged step-like, one above the other, withstand deluges of 25 or 30 inches rain in a day without damage either to walls or the mud-beds of the crop. Terracing was well understood by the pre-Inca race in the Macchu-Picchu and Ollantaytambo districts of Peru; with that almost preposterous field practice they tilled sides of mountains seemingly impossible to cultivate; and the mystery of their stone-fitting in the walls has not been solved. Cook has justly stressed this crop system in an apt comment.[1]

"Terrace agriculture is not only a means of utilizing steep or broken land, otherwise not capable of cultivation, but is also of interest as representing a permanent system of agriculture, in contrast with our ways of using the soil. The

[1] Cook, O. F., "Domestication in Peru," Journ. of Heredity, Vol. XVI, No. 3.

ancient Peruvians were soil-makers, while much of our farming is destructive. By means of terracing, the soil is drained and kept in place so that the fertility is not lost, but may continue to increase as it does in uncultivated lands. The terraced lands of the valleys of the eastern Andes undoubtedly have been cultivated continuously for many centuries and are still very productive. The great antiquity of the terrace system thus has a special significance as showing the possibility of a permanent agriculture, which is the necessary basis of a permanent civilization."

Cross-trenching appears to be a better practice for the average tropical planter. Beginning near the top of the slope, zigzag trenches are cut across the field at a grade that will carry away the surface run-off of rain but leave the loose earth. The earth from these cross-ditches is of two sorts: the good soil from the top of the cut should be scattered over the surrounding ground, while the heavier earth from the bottom should be diked along the lower side of the trench so that it will help to keep the water in bounds.

A valuable accessory to the cross-trench is the silt-pit. Sunk at any convenient point in the course of the trench, a hole, say a yard wide by two long by one deep, will catch a good part of the soil particles which are swept along the bottom of the trench. These silt-traps must, of course, be emptied whenever they become half filled. The contents are well worth saving—the richest part of the soil—and may be used as a food material around trees in coffee cacao, or rubber plantations.

When the low grade of the slope does not warrant the serpentine or zigzag ditches, the silt-traps may be used alone, made longer and set *en échelon* (in steps).

If channels have already been washed in the slope, they should be dammed at intervals with brush or live bushes so set across the gully that the débris and silt will be caught. From these small dams, side trenches should be dug to take

the overflow quietly across the face of the slope, following all contours with a gentle grade.

CROPS FOR THE TROPICS

The easiest way to classify tropical crops is to call them "permanents" and "temporaries." Aside from the deciduous fruits, some forages, and the forests, there are not many perennial crops in the extra-tropical half of the earth's surface. However, in the tropics there are very many permanent crops and, moreover, more annuals and more problems concerning the interdependence and rotation thereof.

The twelve-month season is thrice more difficult than the six-month.

Permanent tropical crops are in theory the nearest approach to an ideal means of livelihood in the whole realm of agriculture. To be sure, the Zulus, the world's best-developed savages, lived for ages a strenuous life, consuming meat, blood, wild fruits, and milk from their herds which roamed the unfenced veld; and the Sulu fisherfolk get along very comfortably on a marine diet,—fish of a hundred kinds, fresh, dried, or "fermented," molluscs, crustaceans, sea-weed for agar-agar and salads, with a little bartered rice and capsicums. But the tropical planter has a very fair meal every time a coconut drops. An acre of these palms yields 2,500 nuts a year, or seven meals a day; there is practically no work, no upkeep expense, no worry, no change for two or three generations.

Looking backward, the modern economist sees many shortcomings in the practices of the permanent-crop producers in most tropical countries in the past. Billions of dollars have been within their grasp, but not quite acquired. This was due to ignorance of scientific principles, indolence for which the climate was blamed, but worse still, a sort of superstitious dread of change. Thus the old-time sugar-planter seeing his cane ruined by pests and blights, could not understand it and hesitated unconscionably long in sub-

stituting resistant varieties and in improving his antiquated practices.

Slowly and surely, however, the new ideas have spread. Now the mental attitude of the tropical planter is strongly in favor of progress based on scientific tried-and-proved methods. If a Java cane-planter hears of some new field practice for controlling his mosaic disease, immediately that new method must be tried out; he writes his Sumatra neighbor about it, and in turn the neighbor tests the practice on his tobacco mosaic; they compare notes, they read over termite-bored bulletins; they get the modern spirit of experimentation; and they very likely, sooner or later, find what they are looking for; and the glory of their success encourages some of the over-conservative on-lookers.

There are six major permanent crops in the tropics, counting the newest one, oil palms. Coffee and cacao start with shade trees and seldom does a catch-crop appear in their domain; yet even in these two cases there is room for argument about the amount of shade and the kind, no perfect sort yet having been found. Tea permits secondary crops only at the very first. Coconuts, oil palms, and rubber offer excellent opportunities for various catch-crops the first ten or fifteen years.

Cover-crops, live mulches, and humus-providers constitute serious problems for the estate manager in charge of one of these permanent crops. He cannot pick up a compendium and note the exact field practices he should follow in any particular case, for no two cases are alike. He must try out this, that, and the other practice which in his judgment might prove of value; and depending largely on his experience, the proving time and expense will be little or great.

Every estate with a heavy investment in permanent crops should encourage the field superintendent and his assistants to experiment: trial plats, variety tests, and in-doors a good laboratory and library. This side of tropical crop work has usually been sadly neglected. In the writer's opinion every

field manager on every permanent crop estate should not only be encouraged to take stock shares in the property but he should be given a percentage—small, perhaps—of the profits. When he remembers that a slackness or lack of personal attention to a particular feature of some special operation will reduce his bonus, there is a decided tendency to get the thing done properly. Percentages offered to chemists and mill foremen in sugar-cane centrals often run up far beyond expectations, but nevertheless they are good economy.

Empirical practices are, or ought to be, good. But no cut-and-dried policy is quite safe all the time; new factors, negative as well as positive, are bound to creep in and there must be men and methods adaptable to every change.

Briefly then, every permanent crop estate should be so managed that the major crop has every possible assistance, adjunct, protection; open-mindedness with scientific caution applied to every nook and corner and every day in the year. It is refreshing to learn that recently many of the great oriental estates are putting eggs into several baskets—very successfully, too; there is now no disgrace in a rubber plantation producing sisal and the oil palm materials; the perspective is expanding.

The banana is a semi-permanent crop. Catch-crops should start with the setting of the first suckers, and permanent crops—coconuts, cacao, perhaps citrus fruits or even rubber—should go in as soon as the Panama disease cuts down the yield below the profit line.

The number of major annual crops in the tropics is small in comparison with what there should be. Until the last few decades there was not much exchange between localities. Burma might have a lot of very superior kinds of asparagus pea (Psophocarpus) but they remained unknown to the Philippines and India; Liberia might grow a rampant variety of cassava giving a crop in six instead of ten months, but it remained of local importance only.

Some tropical temporary crops have been grown in or

near the place of their origin for several thousand years. It is a wonder that they have changed so little; but now that they are beginning to scatter abroad and to be grown under varied conditions they may be expected to change, and new or unrecognized varieties will appear. Artificial associations in plant sociology will cause extra-normal reactions.

The more commerce and ways of living broaden, the more call there will be for diversification of crops in the tropics. Each field devoted to short-season crops should have cultural practices carefully worked out for three to six economic species.

Rotation is now a popular idea everywhere; yet much good land and time is wasted. The fallow-ground resting-period is still in evidence on both sides of the world. Old customs in agrology may become senile, but they live on. Many strange practices have persisted for ages. Since rotation of minor and temporary major crops is very complex, it must be left with the remark that the planter should not accuse one crop of "poisoning the soil" (by its root excretions) until he is sure that no physical factors were contributory.

Aquatic crops.

One very interesting crop system has been deplorably neglected except in some sections of Malaya and southeastern Asia,—aquatic cultures. The number of crops that may be grown not on land but in flowing or stagnant water is, however, amazingly large, around seventy-five botanical species, and of some of these there are forms and varieties, locally named and well differentiated.

These aquatic crops require little attention, take up no valuable ground, and allow the water to be used also for pisciculture. There are virtually three classes of economic aquatics: those requiring water more than one foot deep, those grown around the margins, and the floating species.

To the first category belong the large water-lilies and lotuses (Nymphæas, Nelumbiums, Euryales) and the like.

In the group of shallow-water crops are the Lotus, Typha, Eleocharis, and Aponogeton species—and there are many sorts of them. Of the floaters are the Trapas (four kinds in cultivation), the Lemnas or duckweeds (for ducks), the Azollas, Pistias, Piaropus. Even rice is grown in lakes in Indo-China, and in the Philippines there are one or two sorts that endure brackish water.

This aquiculture practice should be extended throughout the occidental tropics. The minute forms of plant and animal life (plankton) in the fresh and salt waters of the world have received considerable attention—out of proportion, perhaps. Now the water forages, vegetables, seeds, nuts, roots, and grain crops should be studied.

Cover-crops.

Cover-crops are, generally speaking, great blessings to the tropical farmer. Their good points may be summarized as follows: (1) They, being nearly always legumes, gather nitrogen from the air and pass it on to the crop; (2) they protect the top soil from erosion; (3) they keep the surface cool and thus prevent "humus burning"; (4) they furnish humus; (5) they keep down weeds and grass, a very important matter in some cases; (6) they improve the physical texture of the soil, largely by their root action.

The negative features of cover-crops are weak, but worth considering: (1) Harboring pests, from insects to snakes; (2) smothering the crop, in some cases; (3) transpiration of soil-moisture; (4) absorption of fertilizers; (5) hindering fertilizer application; (6) obstruction to laborers' operations.

Covers may be classed roughly as "lows" and "highs." The best blanket covers for both permanent and annual fields are:

1. Cowpea (*Vigna sinensis*); the rare silani (*V. marina*) may eventually supersede the older sister species, because it roots at the nodes.
2. Butterfly peas (*Centrosema pubescens* and *C. Plumieri*) are

quick-growing large vines, popular in the Orient, but native to South America.

3. Velvet bean (*Stizolobium Deeringianum*), a very vigorous species, popular in the Occident; the bush forms should be used when the ordinary varieties might smother the crop.

4. A compea relative, *Vigna oligosperma,* of the Orient.

5. The clitorias (*C. cajanifolia* and *C. ternatea*) are excellent vine legumes.

6. Jack beans and sword beans (*Canavalia ensiformis* and *C. gladiata*) are very coarse but not bad climbers.

7. Kudzu (*Pueraria Thunbergiana*) is a rampant vine not very popular though it is recommended as a hay crop, fiber plant, starch (from roots) crop, and salad (leaves and shoots) plant.

8. Asparagus pea, or seguidillas (*Psophocarpus tetragonolobus*), beats all rivals in a field test in the Philippine Bureau of Agriculture; it has fodder roots and excellent "string-bean" pods for the table.

9. Dolichos beans, as *Dolichos Lablab* the bonavist bean, and *D. Hosei,* are excellent legume vines when conditions are favorable; the former bears perhaps the best of all table beans (when the vines are supported), and the latter is reported as one of the best blankets.

10. Patani or lima bean is really a group of many sorts of legumes, some bushy, others trailing. The patanis of the Philippines are luxuriant vines, quickly covering a large area. The true lima is *Phaseolus limensis,* but the sieva, *P. lunatus,* is often grown as lima.

11. Jerusalem pea of India and Ceylon (*Phaseolus trinervius*), is perennial.

The erect, bushy, green-manure covers are very numerous; some of the best are:

1. Tephrosia (*T. candida*) is probably the very best of all nitrogen-provider species. It grows quickly in all ordinary situations, reaching a height of 5 to 8 feet; 2 pounds of seed plant an acre. Macmillan states that with four cuttings a year 58 tons of green-manure may be taken off. It has been a favorite in Java for years and is now becoming popular in the West Indies. Unfortunately it is unsafe as a forage. It lasts two or three years. It endures shade.

2. Pigeon pea (*Cajanus Cajan*) is probably the best dual-purpose leguminous shrub. Its forage, green or dried, is about equal to alfalfa. It may be cut every few months for two or three years; as a pasture plant in Hawaii it lasts four to seven years. The seeds, green or ripe, are table food containing about 20 per cent protein. There are some thirty varieties in tropical America, ranging from 3 to 16 feet in height.

3. Mimosa (*Leucœna glauca*) is a shrub 10 to 20 feet high, common in both tropics. The foliage is safe for goats and cattle, but

acts as a depilatory on horses and swine. It can be cut back repeatedly.

4. Madre de cacao (*Gliricidia sepium*) is a rapid-growing coarse shrub or small tree. It roots well from cuttings and endures pruning fairly well.

5. The rattle-pods or Crotalarias are popular woody herbs of rapid growth, of no use for forage, but producing a vast amount of lush herbage. They stand 3 to 7 feet high.

6. Hubam clover (*Melilotus alba* var. *annua*) is a form of sweet clover. When provided with the proper nodule bacteria it quickly reaches 5 or 6 feet. The forage is too rich to feed green, but makes a very nutritious hay. It sometimes fails to set viable seeds.

7. Sesban (*Sesbania bispinosa*) is a loose-branching shrub, 6 to 12 feet high in good soil. It is of uncertain value for forage.

8. The tame and wild indigoes (Indigofera spp.) are questionable cover-crops, though in some countries some sorts are much liked.

Control of pests.

Bait-crops are interplanted with others in order to attract insect pests away from the major crop. Maize, for example, is planted around and through sugar-cane to serve as bait for the cane-borer (Diatræa spp.). Pest barrier crops are also used, particularly with tea to hinder the migration of the tortrix.

Incidentally, it may be mentioned here that one of the new methods of controlling such insidious pests as nematodes, root aphids, root grubs, mole-crickets, earthworms, ants (leaf-cutter and girdler), and termites is as follows: A steam-generator is connected to a large rectangular inverted pan, which is placed over the area to be treated and so diked around the rim that the entering steam must pass down through the ground; for ant and termite nests a pipe may be thrust down to the center of the colony, and with the top of the nest tamped tightly the steam follows the burrows and cavities, killing eggs, pupæ and adults. The use of cyanide preparations placed inside these nests is simpler but seldom completely effective—a very grave matter when dealing with the leaf-cutting ants (Atta spp.), which are perhaps the most serious insect pests.

The steam sterilization practice is recommended when

root fungi (Fomes, and others) are endangering valuable trees, like hevea.

Pest parasites continue to vindicate themselves. Some have failed, but many have saved several major crops from dire decimation. The sugar-cane planters are realizing something of the tremendous possibilities in this field practice. There is recently some talk of establishing an international parasite research and breeding institute, whither pest parasites from one country could be sent for study, propagation, and distribution to others less fortunate. This idea is sound.

Not only insect pests can be controlled by this system, but also dangerous weeds. The lantana problem of Hawaii is an example: a small fly and a puny Lycænid butterfly accomplished the great work. And more recently the terrible cactus plague of eastern Australia is being checked. Scale insects, Hemiptera, Lepidoptera, Coleoptera, fungi, and even a Bacillus are being tried at the Cawthron Institute of Science Research; before being released in opuntia stands each parasite is tested as to its possible dangerousness for cultivated crops. Some $200,000 have already been spent in this gigantic scheme to save $1,500,000,000 worth of land from prickly pear, which "has laid waste more land than any other pest plant in any part of the world." [1]

FERTILIZERS FOR TROPICAL CROPS

Crop fertilizers may be classed roughly as natural, artificial, and amendatory. The natural fertilizers comprise animal manures and guanos, from stable urine to phosphate rock and nitrate of soda, although these mineral substances are sometimes classed as chemical manures.

The artificials are the ammonia and potash salts and the various chemical combinations and mixtures, by-products from industrial plants, and the synthetic materials.

Lime, gypsum, salt, copperas, and a few other materials

[1] Tillyard, R. J., New Zealand Journ. of Agr., Vol. XXXII, No. 4, 1926.

may benefit the crop, not as a fertilizer but as an amendment to the soil. By stretching the point, the cultures of bacteria which may indirectly aid the plant in obtaining a better partnership with the micro-floræ in the soil may be included.

Animal manures.

In the tropics more than elsewhere the farmer needs to give attention to the animal residues. The wastage of these manures is a very common item in estate practice the world over, but the treatment of stable refuse to prevent the breeding of both the stable (Stomoxys) and house (Musca) flies is a serious problem in the tropics. Both these pests are dangerous: the Stomoxys takes a very considerable quantity of blood from the animals and, worse still, irritates them constantly from sunrise to sunset; Musca now stands convicted of being the carrier of several diseases.

Until about 1913 little was done to mitigate the Stomoxys and Musca evil. The stable refuse was left about in heaps or at best in open pits and every opportunity was offered for the breeding of these pests in and around the stables, pens, and corrals. When seventeen blood-gorged Stomoxys could be caught in one hand-swipe down a bull's leg at the Alabang Stock Farm, near Manila, the writer determined to devise some means for stopping such a loss of blood. A few weeks after the construction of a large special fly-proof manure pit it was difficult to find a single fly about the stables. The principle is simple but the plan of construction has been varied in both the Canal Zone and Porto Rico.

A pit unit consists of a concrete or water-tight plank base surmounted by a wooden structure—a framework for the roof and the wire screen. The base may be sunk somewhat below ground or set flush. Two or more bins or pits are separated by water-tight partitions 4 or 5 feet high. The solid floor of each pit drains toward one corner, in which is an outlet for the liquid to escape, the opening being closed

either with a large wooden plug or a faucet (on an iron pipe). A bank of earth is thrown up against the front of the manure-pit unit, so that a cart or wheelbarrow can discharge the material, through large windows, over the rim of the solid base into one of the compartments.

Water is put into the section so that most of the manure is covered from the air; this induces an anaerobic fermentation which quickly changes the raw material into a much more available form of plant-food. By this method there is no escape of ammonia, no bad odors, and no flies. From time to time a portion of the liquid is allowed to escape at the drain opening on the back side of the structure; this may be collected in a sunken tank, taken away directly in buckets or barrels to the field, garden, or orchard, or returned to the surface of the manure in one of the sections —to accelerate the bacterial action on the material. This liquid, applied sparingly over the feeding area of a plant, supplies immediately available food to the roots—action in minutes instead of weeks as would be required by the aerobic method.

As soon as one section is filled (and allowed to settle a few days), the drain at the bottom is left open so that the mass dries out ready for removal to the field. By varying the drainage, the settling, or "resting," period, and the amount of exposure to the air, any degree of solidity or friableness may be obtained in the solid material. This fermented manure has been found to be worth about 50 per cent more, pound for pound, than heap stable manure, due partly to there having been no escape of ammonia and partly to the fact that the substances in the manure have been digested, or rendered "available," by the concentrated action of the anaerobic flora.

The pit structure may have at one end one or more sections devoted to compost. Into this water-tight bin are dumped the orts from the stable, yard or kitchen refuse, non-edible vegetable materials from the garden and fields. More water and a longer time are required to rot the coarser

plant materials in the compost sections than in those for the manure. The liquid extract from the compost is good, but, of course, not so rich as that from the manure.

If the stable has a concrete floor, it should drain into a base gutter, and this may connect with a sunken, water-tight, rain-proof tank for the liquid seepage. This tank may also be connected with the manure-pit structure, or each building may have its own reservoir. The concrete or plank (V- or square-bottom) gutters sloping down to the cistern should have a side outlet at or near the latter, which can be opened to discharge washing or rain-water into a surface ditch. The inlet aperture of the cistern should, of course, be provided with a stopper to prevent the entrance of useless liquids. No water containing any sort of disinfectant preparation should be allowed to enter the urine tank: plant-food must contain no poisons.

From a stable with ten horses, some 40 to 50 gallons a day of liquid excreta should be saved by this gutter-and-tank system; the same number of cows or oxen will deliver a little less.

The above-described system works equally well with either horse or cattle manure; refuse from the pig-pen and poultry-house may also be contributed. Stirring over the material in the pit is unnecessary.

Boards may be substituted for the metallic screening of the superstructure, but a portion of the sides should be screened for two reasons: to know whether flies are breeding in the top of the mass, and to detect odors—if the wet-method fermentation is not getting enough water to avoid "heating." A few lizards put into the pit take care of any fly adults that may show themselves on the screen.

If sufficient water is unobtainable for the wet method, the pit is nevertheless a good investment. Without the water, the aerobes generate a high temperature and this drives out the fly maggots. These escaping larvæ must be caught in a level gutter running around the outside wall of the structure which is filled with some larvicide, or even water with a

layer of kerosene. The roof must overhang the structure on all sides to keep out rains.

Compost pits or heaps without roofs are not recommended for tropical estates; unless properly managed they may harbor vermin and the time required for the rotting of the materials is altogether too long.

The points to remember in the use of liquid manure are: partial saturation of the surface soil layer is better than saturation; dilution may be necessary, with young plants, if the extract appears very heavy; it may be kept in barrels or drums in or near gardens, plats, or orchards; it is a forcing solution. Objection may be made to the anaerobic flora of this wet-process for animal manures; while they may not be directly beneficial to roots, they do not "burn up" the humus too fast as the aerobes may do. It should be remembered that each gram of surface soil normally contains several million bacteria; likewise that knowledge of the actions and reactions of nitrogen in the soil is deplorably meager.

Soil inoculation, stimulation and improvement.

Some two decades ago there arose great interest in soil inoculation. The principle is still good but the practice was deplorable. Dead bacteria injected into the bloodstream may be beneficial; but in field practices the transplanted germs should not only be alive but should harmonize with the particular locus of transplantation.

The new seed stimulation idea has merit. If certain chemicals or even cultures evidence positive actions on seeds, the farmer will come to use them. Not alone the time saved at the start (germination) but also the extra vigor of the young seedlings are important items. Some of these "starters" are coming on the market.

There are also now available "patent" compounds, quasi cultures, for hastening the "fermentation" of animal manures and vegetable composts. This looks like a fair field for progress, especially where the soil can produce twelve months in the year.

Two field practices of great potential merit but of little regard in general horticulture are smoking and chemical stimulation. For very long the Filipinos have been accustomed to force mango trees into fruiting by means of smudge fires. In special cases with valuable old trees, lattice-work chimneys are constructed to lead the heat and smoke up into the top of the tree. These flues may be 20 or more feet high, tapering from a mud-plastered base some 5 feet in diameter to the upper portion of about 1 foot. Whether the smoke alone would force the tree into flower out of season is doubtful, but Wester [1] recalls the accidental discovery in the Azores that pineapples can be forced by smoking them. As this practice is known to succeed with these two fruits, it is possible that it may with others.

Bordeaux and other sprays stimulate flowering in citrus trees, presumably through some action of the copper salt. Sugar-cane germination (of cuttings) is hastened by immersion in chemical solutions. Anæsthetics force dormant ornamental stocks into growth and bloom. Ethylene, chlorhydrin, xylol, carbon dioxide, and the like, produce more or less prompt quasi-stimulation phenomena. Therefore, it is only a matter of time and research to control in greater or less measure the physiological processes—flushing, blooming, "setting," maturation, of crop plants. The field is inviting and the reward is great.

Amendments, or improvements, to the soil, such as salt, which liberates potash, and lime, which changes nitrogenous matter from inert to soluble form, are not fertilizers and must be used with great care in the tropics. Each has its good points and should be studied more thoroughly under tropical conditions.

Generally speaking, in tropical regions of fairly heavy rainfall, all manures, fertilizers, and amendments should be applied at intervals and preferably during neither drought nor rainy periods.

[1] Wester, P. J., "Forcing Tropical Fruits with Fires," Fla. Fruit Grower, Mar., 1927.

Aside from sugar-cane the fertilizing practices for tropical crops are mostly empirical instead of being based on definite technical optima. Much has been learned regarding tea, cotton, and tobacco manures, but a vast amount of research is demanded; the tropical planter has even more need to know the scientific reason for every negative as well as positive result eventuating on cultivated lands. Billions of dollars are being lost on the tropical estates through lack of accurate data concerning tilth, water management, fertilization, phenology, prophylaxy, and farm economics.

THE LABOR PROBLEM IN THE TROPICS

Manual labor is the crux in many phases of crop production in the tropics. Ethnology must be respected.

The Tamil from the crowded east side of the Deccan Peninsula is a thrifty, steady, easily managed man; good at routine field operations but poor at mechanical tasks. He likes strong drink and is not highly moral. The women work well so far as their physique allows. As indentured coolies they began coming to the Lesser Antilles and Demerara over thirty years ago. They took the place of the unreliable West Indian negroes on cacao and sugar estates. Many have remained, purchased farms with their savings, and become respected citizens. In the Orient they help keep down the cost of rubber.

The North India coolie is stronger than the Tamil, less apathetic, has better morals, but is seriously inclined to belligerency.

The Malay is difficult, although he has many good points. While interested in a task none can beat him at hard work; if some of his whims come into play he is usually unreasonable and rather ruthless; his mind is quite his own. Coaxing may help, driving hinder. He quickly learns to do difficult mechanical tasks. The Javanese when contented are good laborers, and they have saved the situation on Sumatran estates.

The Chinese coolie is one of the best workers in the

world. Thrifty and steady up to a certain point, he insists on what he believes to be his rights. He gambles, has feuds, belongs to tongs and cliques, works best in gangs. He has ingenuity but is not a student.

The West Indian, and in general the African, is strong when well, and will outdo most laborers as long as he gets some fun out of the job. He works best in small gangs. He is not steady nor thrifty, is superstitious, unmoral, of uncertain temper. He will go hungry in order to buy gewgaws. He works on the "advance" system, at any cost. His judgment is often warped by egotism, but he is a good mechanic when carefully guided.

The tropical American "Indian" is a good worker under certain conditions. He is not very dependable and is inclined to gambling and immorality. He works best on contract, task labor, and requires careful supervision.

CHAPTER II

GEOGRAPHY AND CLIMATE OF TROPICAL REGIONS

Of the tropical lands of the world some 40 per cent are independent (mostly South and Central America), 59 per cent are controlled by European powers, and less than 1 per cent (mostly the Philippines) is under the American flag.

The United States pays over $2,000,000,000 a year for tropical products, over $500,000,000 of which is really an excess charge due to foreign governmental control. By the end of the century, according to Pearl of Johns Hopkins University, the United States will have to import about one-half of its food calories, mostly from the tropics.

About one-half of the arable land of the globe lies within the tropics; in theory the plow can turn over about 30,000,000 square miles of land, and some 14,000,000 or 15,000,000 are tropical. Hardly more than 600,000 square miles in the torrid zone have been cultivated by all the tribes and races of mankind. Some 325,000,000 to 350,000,000 acres are now under cultivation in tropical countries, between 3½ and 4 per cent of the total area. About one-half of this total cultivated area is planted in cereals and about one-fifth in crops for export.

The Tropic of Cancer, running west through the middle of the Bahamas, misses the northernmost point of Cuba by about 20 miles, strikes the continent about 100 miles north of Tampico in Mexico and jumps off just above Mazatlan only to hit it again near the tip of the Lower California peninsula. It takes in practically all of the Hawaiian group but leaves out the Ocean Islands and Midway Island,

enters the Orient in the lower third of Formosa, well to the north of the Philippines, and strikes the mainland at Swatow, just north of east of Hongkong and Canton. Few persons, even travelers, remember that China has over 100,000 square miles inside the tropics, the boundary line extending for over 1,100 miles before it enters Middle Burma. From Burma the line runs well to the south of the tea "gardens" of Assam and seventy-five miles to the north of Calcutta, leaving about half of India in and half out of the tropics. It passes through those murky miasmatic swamps of Cutch, south of the burning plains of Karachi next to unknown Baluchistan, over the Arabian Sea to the deserts of the Kingdom of Oman and then right through the heart of Arabia and out of it, through the new independent Nejd between Mecca and Medina, across the upper half of the Red Sea and over into the scorching sands of eastern Egypt, crossing the Nile some 50 miles south of the great Assuan dam, through the center of the Libyan and Sahara deserts for 3,000 miles and out at the middle of the rainless Spanish colony of Rio de Oro, well to the south of the Canaries; thence straight across the middle of the North Atlantic.

Capricorn crosses the middle of the South Atlantic, entering South America just east of São Paulo in southern Brazil; thence across the upper half of Paraguay into the vast llanos of the extreme north end of Argentina; over the Andes just below Bolivia and out at Antofagasta south of the Tacna-Arica trouble zone. It then passes out across the wild sweep of the South Pacific, keeping above Easter and Pitcairn, missing the far-flung countless isles below the line dotting the sea for 6,000 miles, and, passing under New Caledonia, it strikes Queensland about midway of the east coast at the end of the Great Barrier Reef, crossing the desert region in the center of the continent and emerging near the extreme western point of West Australia, thus leaving nearly two-thirds of Australia in the south temperate zone. It thence crosses the southern Indian Ocean, run-

ning just below Mauritius and Reunion into the lower and almost unexplored end of Madagascar, entering the Dark Continent at the dreary old town of Inhambane in southern Portuguese East Africa, crossing the exceedingly fertile but still unsettled plains of Gazaland into northern Transvaal and Bechuanaland, and coming out near Walfish Bay just below the middle of the great dry Southwest Territory recently taken under the ægis of the Union of South Africa.

TROPICAL AFRICA

A rather large proportion of tropical Africa is too dry for intensive farming; some is too high; and some areas are practically unexplored. In Kenya, formerly British East Africa, the coastal area is hot and dry, while the mesa of the hinterland is virtually temperate, where the cereals and several of the major crops of Europe and America do very well. Transportation problems are troublesome. Cotton, maize, tobacco and live-stock are fairly successful. Peanuts, sweet potatoes, millets, and flax will probably expand in acreage.

Benadir, or Italian Somaliland, just north of Kenya, stretches 1,000 miles from Kismayu to Cape Guardafui. Droughts are severe, but ragi, kafirs, and the hardy "groundnut" (Arachis) yield a small surplus.

South of Kenya, the large block of Tanganyika, once Deutsch Ost-Afrika, occupies a section of rough territory running from the Zanzibar coast back to the great lakes. The Germans planted coffee and sisal extensively. During the Great War these crops suffered, but sisal soon recovered and now the export runs to 25,000 tons as against some 14,000 in the German régime. Flax is doing well and should be extended. In the high interior the temperate grains can be raised successfully. Cattle and goats thrive where they can be attended properly.

The upper and middle parts of Mozambique are tropical and comprise some of the finest cultivable lands in the world. North of the Zambezi sisal does as well as in

Tanganyika. Sugar-cane lands of the highest grade stretch away across this great valley which is Portuguese for 500 miles (from Chinde at the mouth to the western end of Tete Territory). Cotton and rubber have been tried thoroughly, since the beginning of the century, by the Companhia do Moçambique in the central district. Here in the deep alluvial soils between the sea and the foot-hills of the central mesa, forage grasses stand 6 to 9 feet high, kafir millet 15 to 20 feet, and maize luxuriates; antelopes of many species, zebras, and even giraffe but no cattle as yet.

On the Red Sea south of the Tropic of Cancer stretches for 500 miles the desert shore of Upper Egypt down to Eritrea, the Italian colony lying at the door of the unconquered mother country, Abyssinia. It is dry and desert-like, but commercially important. Next below lies the Côte des Somalis, Djibuti, or French Somali Coast; here begins the railway running up to Adis Abeba, the unique capital city of Abyssinia. Between Djibuti and Benadir is the British Somaliland Protectorate, 400 miles from east to west and practically a desert throughout.

Abyssinia, the largest independent negro country and the only one a kingdom today, has an estimated area of some 200,000 square miles. The interior is mountainous and the center has several peaks about 14,000 feet high; in the little-known southwest there is a series of lakes. Here may have originated several tropical grain crops, the chick-pea, ragi, perhaps some of the African millets, and coffee.

From Djibuti on the Red Sea to Dakar in Senegal it is some 4,000 miles, a year's hard travel, along the southern edge of the greatest desert. From Zanzibar, along the 6th degree of South Latitude, Africa is only about 1,900 miles wide, yet it might take longer to cover these straightaway, than the 4,000 across the Sudan.

The Anglo-Egyptian Sudan, sweeping westward from Abyssinia and the Somali countries, is largely unknown. Some parts are desert and there, also, are perhaps the largest swamps in the world—papyrus by the tens of thou-

sands of acres. No one can say what agriculture will eventuate in this far region fifty years hence.

Farther west and southwest lies the almost limitless Tchad, or French Sudan, the northernmost section of French Equatorial Africa. Many parts of the Tchad Territory are populous, dry in the north but wet down toward Moyen Congo—the middle reach of the not yet delimited French Congo.

West again from Lake Tchad and Timbouctou, the great native empires of Upper Senegal and Niger Territory extend toward the Atlantic Ocean. They support all sorts of dry-land crops, live-stock, some forests, vast open pasture lands dangerously dry in the rainless season. The great Niger, rising over near the West Coast, and comparable to the Mississippi, flows for hundreds of miles eastward, then turns south down through British Nigeria.

Senegal proper reaches the coast between the small but busy British colony of Gambia and the desert colony of Mauretanie, which, with Spanish Sahara Occidental, forms the western boundary of the Sahara Desert. Gambia and the neighboring Senegal country are famous peanut-producing regions. In good seasons most of the tropical grains may be raised in this dry part of the "heel" of Africa.

Farther south in little-known Portuguese Guinea and next in French Guinea the climate improves and the crops multiply. The former is practically unknown while the latter has a rather busy railway running back from Conakry into the very wild hinterland whence come vast quantities of peanuts, shea-nuts and -butter, and hides and skins. The oil palm and kola do not extend quite so far northward. It is a great place for millets and pigeon pea should do very well.

Sierra Leone is a typical British West African colony. Along the swampy coast there are several districts wholly under British control, some 4,000 square miles. Here there are many plantations of ginger and small grains. From the bustling capital, the port of Freetown, there extends a nar-

row-gauge line away back to Pendembu in the easternmost corner on the Liberian border, with a branch running up northward into the center of the undeveloped Protectorate, an expanse of some 27,000 square miles occupied and largely ruled by native chiefs and petty kings. Mostly from the higher and less droughty hinterland come 65,000 tons of palm kernels (from over 500,000,000 pounds of nuts), 3,000 or more tons of low-grade ginger, and considerable quantities of sesame and piassava palm fiber. From the far northeastern corner of Liberia, largely, the aforementioned railway collects, over many tortuous foot-paths through a very interesting and potentially rich half-forested country, no less than 6,750,000 pounds of kola nuts for export mostly to Europe. This region is too dry, perhaps, for rubber but maize and the small grains could be grown extensively and sisal would do well presumably. Cacao is starting in the extreme south corner.

Next to the south, on the angle of the "heel" of the African boot, lies Liberia, the only Old World negro republic. It comprises a strip of civilized country along the coast, a few miles wide, and along the banks of the great St. Paul River in the north and the Cavally in the south. The bulk of the remainder stays nearly as it was five centuries ago; the boundary has been surveyed after a fashion, and the area is probably around 40,000 square miles.

In the center of this Black Republic there is a region—about one-third of the total area—inhabited by two or three branches of the Jawquelli tribe, who long ago declared war on the remainder of the world, including particularly the civilized and nominally ruling coast people. On the edge of Jawquelli-land was planted just before the Great War a Pará rubber plantation and by 1919 an English firm began to reap the benefits of this strange venture. Whether this nucleus can be expanded successfully into a tract of a million or more acres, as has been projected, is a very interesting question. The climate and soil are apparently as good as could be expected. The local labor is precarious,

but has many good qualities; with extra good management and good luck it should prevent the Orient from monopolizing the rubber crop. In this region are found piassava by the hundred tons, palm kernels by the shipload, palm oil of all grades, pineapples running wild by the mile, cassava everywhere, drugs of high value, kola at home, the native coffee which has gone hence all around the world, grains of Paradise pepper. Here are the last if not the largest of the old virgin forests of the Dark Continent.

The Ivory Coast is likewise little opened up, except near the coast. The hinterland needs much capital and many men. The wealth of oil palm products, kola, piassava, and peanuts is awaiting exploitation. Cacao should do well in the low country, and coconuts might be planted where there is neither danger of sour soil nor drought.

Gold Coast has been talked about more, perhaps, than any other West African colony. Never till the cacao exports assumed international importance, however, in about 1914, did the ports of Accrá and Secondi become prominent. Some features of the great Gold Coast "cocoa" trade are brought out in Chapter V. With her two railway lines tapping the greater part of the populous interior, and truck roads feeding freight thereto, there should be a steady if not rapid development of the hinterland. The total area of the colony is estimated as 82,000 square miles. There is an excellent forestry service. Rubber has been tried. Khaya, or West African mahogany, has been a major export for years. Cotton may succeed in a few districts. Maize, millets, peanuts, and oil seeds and, of course, the indigenous oil palm promise well. This and the neighboring colonies should raise cattle and goats on a large scale, in those higher and drier locations not infested with the tse-tse fly.

Togo was divided up, after the Great War, between France and Great Britain. French Togo may be regarded as virtually a part of Dahomey. Though not yet commercially developed, Dahomey has some of the finest oil palm forests in the continent. Excellent stands of khaya,

as well as kickxia, or silk rubber, are prominent features of the hinterland flora.

Nigeria is really one of the great countries of the world. Its import and export trade figures now run to some $150,000,000 a year. The area of the combined northern and southern provinces (including Lagos) is about 330,000 square miles; and the population is probably around 15,000,000. Kano, the old Bornu stronghold, is now a city of 35,000 inhabitants; trains run thither from Port Harcourt, near Old Câlabar, and from Lagos, near the west boundary. Much of northern Nigeria is too dry, while vast reaches of the southern territory are swampy and insalubrious. However, the variety of crops and raw materials is hardly equaled by any other African country.

Just which major crops will lead here in a decade cannot be foretold. Cacao is increasing, the present output being some 50,000 tons a year. Coconuts and rubber could go in on a large scale in the south, cotton and grains in the central region, and grains, sisal, dates, in the drier north. Nearly 4,000,000 head of cattle are on the census.

The Cameroun, Cameroons, or Kamerun (French, English, and German) is one of the richest regions of Africa. It has rain, all ordinary elevations, a lavish flora and fauna, virgin forests, and a teeming though hardly known native population.

Spanish Guinea is a mere name now. Rio Muni, as it was once called, has never developed. Fernando Po, Annobon, and Corisco, islands in the great Gulf of Guinea, have been written up considerably; the first grows cacao in competition with its more important Portuguese neighbors, the islands of São Thomé and Principe.

French Equatorial Africa is the new name the mother country has given to this vast triple-territory region of Gabun, or Bas Congo, on the coast below Spanish Guinea, Moyen Congo above the northern portion of the Belgian Congo, and Tchad, the little-known and almost unexplored country running away up to the Sahara between Lake Tchad

on the west and the boundless Anglo-Egyptian Sudan on the east. The total area may run to over 500,000 square miles when surveyed.

The Congo Belge, or as it is also sometimes called État Indépendent du Congo, comprises nearly 1,000,000 square miles, with very little waste land within its boundaries. In the great Katanga highland of the southeast are open hilly velds, and the second greatest river system in the world, with its twelve large tributaries on the southern watershed and several more coming down from the heart of Africa, covers one of the best assortments of alluvial soils in any continent. Plantations of oil palms and fields of cotton have been laid out and some small success has obtained. Copper and rubber have brought fame or notoriety to this great country. Hevea would undoubtedly thrive in many districts in this 3,000-mile-long valley. Coconuts, cacao, coffee, cotton, and cane could be produced here, as well as grains and root-crops. The pigeon pea may have originated here. Many potentially commercial products are still waiting in the dense forests and far-ranging velds.

Portuguese Congo, or Kabinda, on the coast just above the Congo mouth, is a rich wild country of a few hundred square miles. Just across the river lies Angola, Portugal's biggest colony, nearly 500,000 square miles. The greater part of the hinterland is high and dry and hence open to cereals, cotton, tobacco, fruits. Millions of acres here will be profitable some day. Coffee runs wild and is also somewhat planted. It promises to be a great live-stock country of the future. The southern part is dry but irrigation is possible.

Rhodesia, now divided by the Zambezi into the southern and northern territories, is developing. It is mostly elevated and subject to drought troubles in places, but adapted for live-stock pastures and grain fields. Maize, cotton, and tobacco should thrive as major crops.

Over to the east lies the Nyasaland Protectorate, which twenty years ago was British Central Africa. Cotton and

sisal, tobacco and maize promise well. There is no need to worry about transporting these materials out of the heart of the continent, for the busy port of Chiromo on the Shiré River (from Lake Nyasa) is some three days above the Zambezi estuary at Chinde in Mozambique.

Away to the north of the Congo Belge stretches that limitless residuum of the mid-African territories—the Anglo-Egyptian Sudan. The area and population are unknown and the future status is vague.

CENTRAL AMERICA AND MEXICO

Central America begins in that wild exceedingly dangerous and unsurveyed strip of virgin jungle claimed by both Colombia and Panama some 150 miles to the east of the Canal Zone. Here grow the largest bananas the writer has ever seen (19 feet to the bunch base), the tallest maize (19 feet to the tassel tip), the largest coconut (the Chocó) and the best (the San Blas).

Eastern Panama is just beginning to export coconuts, sisal, and fruits of all sorts. The western has long been producing some of the best coffee and cacao in the world. Yet it is largely a nearly trackless jungle; there are Amerinds, but little less savage than those of the eastern side, living all through it, but not in villages. Bananas and coconuts do very well.

Costa Rica has long been one of the greatest banana countries. Cacao, coconuts, and recently pineapples, are major crops. With its varied elevations, nearly all the temperate food plants are grown in addition to the tropical. Perhaps no other country, at least in the western hemisphere, has such a great variety of fruits, root-crops, and grains. Though Pittier [1] has listed several hundred useful plants, many others are left in the high and low forests.

Nicaragua is two countries: the swamps and low flat flooded plains of the eastern three-fourths and the high, hilly, dryish western fourth. Few know what is in the

[1] Pittier, H., "Plantas Usuales de Costa Rica," 1908.

wild interior, though refugees, gold prospectors, and hunters go through. Few countries have more game animals and birds, water and land species, fish, mahogany, cohune palms, and rare woods. Coffee and cacao do well. Coconuts along the east coast, with twenty feet of rainfall and ten feet of black soil, bear in three years. It is the home of Pentagona cacao. Maize has always been one of the main food crops. The usual tropical crops can be grown well, so far as soil and climate are concerned.

Honduras is higher and dryer. It has pine forests in place of the cohune swamps of Nicaragua and banana plantations of the best and largest. Fruit orchards, even with mangosteens, are expanding. Coconuts are good along the north coast and on the Ruatan islands.

Salvador is, for its size, the greatest coffee country in the world. Cotton and tobacco are expanding. Barajillo (*Meibomia Rensoni*), a close relative of the pigeon pea or gandul, is peculiar to this region. Chicle abounds.

Guatemala is also rich in coffee as regards the higher and hilly central and western portions. The east is mostly steamy swampy jungle. Many excellent fruits are peculiar to this region: several annonas, the coyo (*Persea Schiedeana*), sapotes, lucumas, and strange members of the rose family. Almost any temperate or tropical zone food plant, fiber, or forage can be produced here. The northeast invites exploration.

Belize, or British Honduras, is a murky, rich, low-lying colony abutting on Guatemala to the west and Quintana Roo, the new Yucatan, to the north. It possesses valuable timbers, cohune by the thousand tons, chicle by the ton.

Southern Mexico is almost too rich. Bananas, sugarcane, maize grow almost too rank. In the jungles giant trees set a record for stands of timber in the tropics. Cacao of the best, Soconusco, is produced, also coffee, cotton, and many fine fruits. The high mesas of the middle region are temperate zone lands, though south of the line of Cancer.

Grapes, oranges, apricots, olives, figs, plantains and avocados are grown, live-stock of all sorts, and game. There is a wealth of truck lands whence train-loads of "winter vegetables" can be exported northward.

WEST INDIES

A few miles east of the Yucatan Peninsula, once so famous for its monopoly of henequen, lies Cuba. About one-third of the world's cane-sugar is produced here, exceedingly cheaply. Tobacco is also an important crop, one valley at least producing a leaf as good as any and more famous.

Haiti next to the east was once a prosperous country. Recently efforts are being made to restore some of its ravaged lands. The finest pineapple field in tropical America is in Haiti, and the best logwood. Sisal is going in. Cotton of a queer type, 8 feet high, and also a purple-leaved species is planted. The island is dry but not desolate.

In Santo Domingo some of the old pine and hardwood forests are left in spite of the practices of the hill dwellers. The valleys have excellent soil. Cacao, coffee, cotton, coconuts are produced cheaply, and probably the cheapest milk in the world. Guinea grass grows 6 feet high, wild, practically. Rice has been planted recently.

Porto Rico has set a record for agricultural and trade prosperity during the past quarter century. From almost no exports in 1898 the trade figures have continued to increase till now they run to $108,000,000 exports and $98,000,000 imports a year; and only about half a million out of 1,400,000 to handle most of this business. Five hundred food plants are in evidence, about one-third indigenous, one-third introduced by the Spaniards, and the remainder brought in during the American régime. The Philippines can equal this, barely, but probably both India and Malaya would fall short of this great display. Yautías thrive in Porto Rico, also coffee, tobacco, pineapples, and

citrus fruits of the very highest grade. Sugar-cane technique is bringing success out of failure.

In Jamaica, bananas are expanding, the harvest being 50,000 bunches a day. Allspice is a monopoly. Coconuts and even copra, kola, logwood, and recently citrus fruits are being produced.

The Leeward Isles comprise St. Kitts and Nevis, Antigua, British Virgin Islands, Tortola, Montserrat, Barbuda and Dominica. Here is, perhaps, the cradle of the Sea Island type of cotton. Cane and citrus fruits are raised. Montserrat has long been famous for its lime and papaya industries. Dominica, the most nearly virgin of all the Antilles, possesses mangosteen groves, the largest outside of the Orient, unexcelled lime orchards, and an excellent botanic garden.

Martinique has a little sugar-cane. Guadeloupe, with its magnificent mountain, has a variety of elevations and has recently become one of the greatest vanilla countries.

Barbados has long been famous as a great cane center.

In the Windward Islands Grenada is famous as one of the few countries where cacao is produced, and very successfully, without shade. Nutmegs and kola do well here. The adjoining chain of the Grenadines are uninteresting but have a chance as pasture islands, a good place for the local spineless opuntia (*O. rubescens*) to demonstrate its superiority.

St. Lucia and St. Vincent are trying to produce bananas. Arrowroot was once the great crop. They now grow some of the best Sea Island cotton in the world.

Trinidad and Tobago have long been prominent in tropical agriculture. Rubber, cacao, coconuts, cane, and now coffee and citrus fruits are prominent features. A nearly ideal climate has this "Iere" of the Caribs where a few thousand years ago West Indian agriculture began to spread northward from the Venezuelan mainland. The botanic garden is one of the best, and has done much good.

Curaçao yields semi-wild orange and divi-divi.

SOUTH AMERICA

While the greater part of Brazil has never been under any form of cultivation, small areas here and there along the coast and river margins have been cleared and planted by bands or small clans of various Amerind races. From western Brazil the pre-Inca races may have emerged seeking a higher and drier land, wherein they laid the foundation for that great land cradle which saw the beginning of so many food crops. They probably domesticated the pineapple; the mani, cacahuate, or peanut; perhaps the cassava, or mandioca, one of the greatest food crops. One hundred or more new economic plants, fruits mostly, have been brought into civilized agriculture during the last four centuries. Both the high and low lands of Brazil are full of Annonaceæ, Myrtaceæ, and Leguminosæ of high merit. The hevea of Brazil has a value of nearly $1,000,000,000 a year. Brazil has a large acreage in coffee and produces more than any country in the world, particularly in the states of São Paulo and Parana.

The Guianas are rich, wild, thinly settled European colonies lying just east of Venezuela on the north coast. Demerara, or British Guiana, is the most important, most populous, and best developed. Sugar-cane, rice, balata, and cabinet woods make up most of her exports. Herds of cattle are raised back in the higher pasture lands in the interior and driven, when weather and trails permit, down through score after score of miles of jungle to the coast. Coolie labor from India made possible the development of Demerara as it is today.

Surinam is Holland's only continental holding outside the homeland. The Curaçao group, Saba, St. Eustatius, and half of St. Martins are small islands, Curaçao, just off the Venezuelan coast, having some commercial importance. Dutch Guiana still produces some good cacao but the witch-broom disease and Gold Coast competition have made grave trouble. The hinterland forests are full of interesting economic plants. The alamoen, a citrus fruit of uncer-

tain taxonomy, is supposed to have originated here; perhaps the grapefruit itself may have "sported" from an Old World pummelo brought to Surinam from some Dutch East Indian garden.

Cayenne, or French Guiana, is one of the least known of all tropical countries. It is a question even whether cayenne pepper originated there.

Venezuela, with its 365,000 square miles and varied types of land, is a country of great agricultural possibilities. The vast llanos, where formerly cattle were hunted for their hides, are being developed. The dense forests in the south and west are full of valuable timbers, rubbers, gums, and oils. The intense excitement over the great petroleum industry around Lake Maracaibo has overshadowed any agronomic interests, at least for the present. Though there is much poor dry land in the north, there are large areas where some of the world's best cacao and coffee are produced. There are also vast regions where cassava does well. Citrus fruits should be planted, at least to meet the growing domestic demand. Some temperate fruits, peaches, quinces, are produced in the high elevations in the north. A rare species of avocado and a number of cherimoya-like fruits are found in the Caracas Valley. Cotton, tobacco, and maize should be stressed.

Colombia is one of the most interesting of the South American countries, from the agriculturist's viewpoint. It has all sorts of soil, climate and topography. It is exceedingly rich in its own fauna and flora, so far as investigations have been made. Cinchonas, heveas, sapiums in the forests; vanillas, aroids, legumes, passifloras, rubi in the half-open country; excellent pastures, banana lands, coffee country; some desert in the north; some of the wettest regions in the southeast, *i.e.*, in the northwestern corner of the Amazon Basin. Many kinds of maize, potatoes, root-crops, and fruits are peculiar to Colombia.

Ecuador, Peru, and Bolivia constituted most of the old Inca Empire. Here were domesticated sixty or seventy

food plants, some six of which have greatly changed the world's food problems. The sound, if not scientific, engineering and agronomical policies and practices of the Incas were astounding. With no precedents or outside influence those farmers surpassed every other race in several lines of accomplishment; if they had invented the wheel and developed zoötechny (for food and draft purposes) their agricultural system would have been nearly perfect. In this region the human race, it appears, for the first time solved the problems of growing food crops continuously on the same ground and of storing the food safely and well.

Ecuador has long been famous for its cacao, tagua nuts (vegetable ivory), and jipijapa, or Panama-hat fiber. Like Colombia it produces some strange kinds of maize, potatoes, and mountain root-crops. Quinoa, the minute-seeded pigweed cereal, is indigenous along these high reaches between the Andean chains.

Peru is becoming a great sugar and cotton country. New valleys are opening up. Old irrigation systems, after four centuries of disuse, are being rehabilitated. Rain has come to some districts recently for about the first time in scores of years. Some of the soil is extremely rich. Alfalfa, of a high grade, appears to have originated here.

Bolivia, like her two neighbors to the northward, is a double country: high and dry on the western slope of the main Andean chain, and hot and wet over on the little-known eastern slope. Strange cereals, root-crops, and fruits invite study.

TROPICAL ASIA

Practically every one of the fifteen main archipelagoes of the Pacific lie within the tropics. The groups of most importance are in order: the Sandwich Islands, now called the Territory of Hawaii; the Philippines, with 1,750 islands (7,083, counting the small ones), about 9,000,000 inhabitants speaking forty languages, and great possibilities; the Fiji group of over 200 islands; Samoa of complex political history; the Solomons, now all British, wild

and vast (some 10,000 square miles); the New Hebrides, jointly governed by France and Great Britain; the Societys, with Tahiti (600 square miles) as the main feature; New Caledonia (240 miles long) with its dependencies, Wallis and Futuna Islands, the Loyaltys, and others, all French; the Marquesas, French; the Gilbert and Ellice groups, British; the Carolines, really three archipelagoes with hundreds of islands, now a Japanese mandate; the Marshalls and the northern Mariannas, Japanese since the Great War; the Tongas and Cooks, British; Guam, at the south end of the Mariannas, taken over from Spain in 1898; the Paumotus, French; and scores of more or less isolated islands, some still uninhabited, some developing rapidly, like Nauru, on account of its phosphate deposits.

In the East Indies two islands are so large that they are practically continents: Borneo with its 286,000 square miles and Papua with about 313,000 (about eighty-seven times as large as Porto Rico). Borneo has two British and one semi-independent (Brunei) colony, but by far its greater part is Dutch. The eastern third of New Guinea, or Papua, is British, the remainder Dutch and half explored. Sumatra in the extreme northwest contains between 160,000 and 170,000 square miles (1,115 miles long) but only some 4,000,000 to 5,000,000 inhabitants including the thousands of coolies recently imported to work on the rubber, tobacco, and oil-palm plantations; from 1905 to 1917 the population increased 26 per cent. Java (only a little larger than Cuba) is one of the most densely inhabited countries in the world; in 1886 it had about 11,000,000 inhabitants—today there are estimated to be no less than 35,000,000. Celebes, next in size, is supposed to have about 75,000 square miles, though its extremely irregular shape renders its mensuration very difficult; it is prosperous where the civilized natives have displaced the aborigines, and very interesting. The Sunda Islands,—Bali, Lombok, Sumbawa, Sandalwood (Sumba) and Flores—are compact little countries, each with its distinct peoples, customs, crops, and

PLATE II.—Primitive method of planting upland rice by means of sticks, Mindanao, Philippines.

breeds of animals. Timor, mostly Dutch, has two areas belonging to Portugal. The famed Moluccas, or Spice Islands (over 40,000 square miles) whither sailed the Portuguese, Spanish and Dutch traders to load with nutmegs, cloves, and pepper when the East began calling the West four centuries ago, is comprised of Gilolo, Ceram, Buru, Ternate, Tidor, Amboina, and a host of lesser isles—each with several trade commodities (raw vegetable oils, cabinet woods, dammar) and plenty of commercial opportunities yet to be exploited.

Nearly half of Australia lies north of Capricorn but except in Queensland most of this area is too dry for agriculture.

Except for Portuguese Timor and British Papua, Sarawak, North Borneo and (virtually) Brunei, the East Indies is really Dutch Malaya (Nederlands Indië). British Malaya, however, aside from the Bornean colonies, is continental. The Straits Settlements (*i.e.*, Singapore and Penang islands and three provinces on the mainland) have dominated certain features of the Far Eastern commerce for over a century. The Malay Peninsula, nearly 1,000 miles long, has for the most part gradually come under British influence. Johore, at the southern end, is still nominally quite independent, and the Sultan has rejoiced that he followed the advice of English experts and went in heavily for Pará rubber even before the great boom of 1910. Kelantan, Trengannu, Perlis, and Kedah are also independent states, largely in dense jungle still. The "F. M. S." (Federated Malay States), comprising Perak, Pahang, Selangor, Sungei Ujong, and Negri Sembilan, are examples of what capital and practical science can accomplish in the tropical wilderness, despite great sanitary and labor difficulties. Siam used to extend down the long neck of the Malay Peninsula and had an area of 195,000 square miles, but some little curtailing has been done; known mainly for her cheap and bulky rice which feeds millions in the far corners of the world, she has a wonderful hinterland, the mysterious Shan

states; she has a solid self-contained government adapting itself to a typically oriental collection of peoples and their conservation, and to her tremendous agricultural possibilities.

Indo-China, the site of some of the first attempts in the world at civilizing the tropical wilderness, extends some 1,200 miles from Cape Cambodia to the south China frontier. Cochin-China, Cambodia, Annam, and Tonkin, each with its problem and wealth of agricultural opportunities, make up this vast French colony.

Disregarding the great stretch of Chinese territory south of Cancer's line and the lower half of Burma with its steaming jungles, the Tropic passes through the scenic ranges of Assam, cool and misty, into the torrid low plains of central India. About one-half of the 1,750,000 square miles is tropical. India has one of the most truly rural populations of the globe: 90 per cent of the people live on farms (in the broad sense). There are 325,000,000 inhabitants of forty-five distinct races, speaking 170 languages. Two-fifths of the land is comprised in the numerous feudatory states with a combined population of about 75,000,000. Portugal still holds four small territories on the coast, and France has three. Here some, at least, of the basic ideas of agriculture were first worked out. Admitting that twenty crops were first domesticated in the central Andean region—probably about the same time that similar work was accomplished in India,—the latter country must be credited with much fundamental progress in the art of getting food from the land.

Much of the regions just outside the zone—Baluchistan, southern Persia, Mesopotamia, northern Arabia, and most of Asia Minor—are practically frost-free, and dates, citrus fruits and the like are widely cultivated.

TROPICAL CLIMATES

The climate of the tropics is supposed to be more or less enervating and many of the torrid zone climes have

long been regarded as pernicious and some regions exceedingly dangerous to the white race. Several regions in the tropics have been cursed with fatal diseases, several of which are on a par with the worst temperate zone diseases; but the climate has been unjustly blamed as the primary or secondary cause. A new light is illuminating this subject. Now that scores of thousands of intelligent persons have tried both and found that the intemperate climate is outside of the Cancer-Capricorn belt and that temperatures frequently run higher in the north temperate zone than in the tropical, the old misunderstanding is disappearing; hence the paradox of tourist trips from the north to the tropics to avoid the great heat of the intemperate zone in the summer.

There are really four kinds of tropical climates. The low wet type is the one usually in the mind of the northern stay-at-homes. Most of the tropical land area in South and Central America and central Africa falls into this class: rainfall 50 to 300 inches, elevation below 2,000 feet, temperature 75° to 95°, winds light; Pará and Manila are representative.

The low dry type is not so much under discussion, but is nevertheless quite distinct. The arid and semi-arid low regions in India, Africa and western South America are extensive. The rainfall is 0 to 25 inches, temperature 75° to 100°, winds uncertain: Lima and Aden are representative.

The insular type of climate is very common. Its characteristics are trade-winds, monsoons and strong breezes from 9:00 A.M. to 4:00 P.M.; temperature moderately high but much mitigated by the air movement. Most of the East and West Indies and the Pacific archipelagoes are examples.

The mesa type includes the plateaus up to 9,000 feet—torrid zone with temperate climate. The temperature is very steady, almost too much so in a place like Bogotá where the monthly mean hardly varies 5° in the year; wind

usually light; rains moderate. The Mexican tableland is representative. In this connection it is worthy to note that elevations of over 7,000 feet are dangerous to individuals born at sea-level: the pulse and respiration rates are speeded up some 10 to 20 per cent and the nerves feel the strain. Plateaus like those of Africa, beginning in the hinterland of Liberia and running 4,000 miles eastward to the Nairobi country of Kenya, can produce a great variety of subtropical crops whenever the temperate zone needs such assistance, for example, cotton, maize, flax, peanuts.

The old bogey of the "miasmatic furnace" is passing. Man is now learning how to live comfortably and safely in the tropics, and the next generation will have few qualms in that direction. The temperature is nothing to worry about; many whites have spent a quarter of a century or so among the browns, reds, blacks and yellows within the tropics and they, almost without exception, abominate the winters of the North much more than the all-summer climate, and justly so.

High temperatures do occur in the zone, but the highest have been recorded outside; several places in the north temperate have records of over 120° F. and the maximum shade temperature is supposed to be about 127°. Few tropical localities ever exceed 95°. The writer, having resided in Singapore, Kingston on Jamaica, and Manila—three of the hottest cities in the world—does not hesitate to state that greater discomfort is felt at times in the United States than in any tropical country. People die by hundreds in northern cities every summer from heat-exhaustion. Heat-stroke, or heat-exhaustion, is rare in the tropics and sunstroke is almost unknown. The shade is nearly always fairly cool—in the 80's or lower. There is usually a breeze from some direction. Ordinarily the nights are comfortable. In short, there is very little actual discomfort in the tropics on account of high temperature.

The humidity is in places rather high but this is just as true of the north temperate zone. A moist air is probably

better for the lungs and skin than a dry one with its concomitant dust.

During the third-quarter months there are hurricanes in and to the north of the neo-tropics. From the eastern Pacific to Sumatra and Japan there are typhoons, the bad ones rare but the ordinary ones sometimes come in groups. The monsoons of the Indian Ocean are very regular and seldom dangerous. The cyclones of North America are undoubtedly more devastating than the hurricanes and typhoons combined. The storm-center moves only a few miles an hour, hence with cables and barometers these storms are in a measure provided against. In the Orient the marvelous typhoon detector, invented by Father Algué of the Jesuit Mission in Manila, has saved hundreds of ships.

Water-spouts are not confined to the tropics. In fact, they are not, as commonly believed, confined to the sea. They reach their climax probably in Lake Lanao, Mindanao, where the water in one of the largest (twenty miles across) craters in the world is almost daily churned by them.

Lightning is about equally common and as destructive in one zone as another. Old geographies used to state that the Amazon Valley had its daily thunder-shower. Most tropical countries have thunder-storms only at the "change of season" times; not a rumble is heard in many places for six months at a time.

Generally speaking, there are two rainy seasons, one usually longer than the other, and one long, one short dry season. But in the tropics, as elsewhere, "abnormal weather is normal"; it really seems as if the logical regular season never appears on time and never behaves according to meteorological precept. Now that weather records extend over decades, meteorologists are trying to discover a rhythm, wave-like, in droughts and rainy periods; for example, it seems that about every eighteen years in the West Indian region there are several consecutive bad

drought years. One of the most striking instances of change of climate is that which began rather suddenly in western Peru and northern Chile about 1924; in a region where rain was practically unknown it began to rain; and this affects the price of sugar, for now another valley or two are being planted with sugar-cane. The change in an ocean current brought about the changed climate: what made the current flow out of course is a deep mystery.

Presumably all climates are slowly changing. Within a few thousand years the whole eastern half at least of the Sahara has gone dry. Vast cereal fields and fruit groves, in the days when Carthage ruled the North African coast, stretched for hundreds of miles where now the sand blows and drifts.

The lay conception of a tropical climate is criticized by the Australian Department of Health [1]: "To the great majority of the inhabitants of temperate climates the word 'tropical' conjures up visions of sweltering mangrove flats, the haunts of the crocodile; of rank and steaming forests that exhale the musty odour of decaying vegetation and conceal within their depths 'miasmic' swamps; of deadly snakes and of the skulking savage with his poisoned spear." And from the same source, "Australia has the unique distinction of having bred up during the last seventy years a large, resident, pure-blooded white population under tropical conditions. For a considerable time it has been more and more apparent that the question of the possibility of establishing the white man in tropical countries possessing no large native population, is infinitely more largely a question of preventive medicine than a question of climate."

[1] Cilento, R. M., "The White Man in the Tropics." Service Pub., No. 7, Dept. Health, Commonwealth of Australia.

CHAPTER III

LIVING CONDITIONS FOR THE TROPICAL PLANTER

THERE are two schools embodying rather divergent opinions regarding the mode of living in the tropics. One, the old conservative, contends that the white race tends to deteriorate in the tropical climes and that no amount of exercise and no kind of diet can avoid a nervous degeneration if not physical breakdown in any individual, male or female, who, born in the temperate, attempts to remain more than a year or so in the torrid zone. The other, the liberal school, maintains that with proper diet and exercise one can be just as vigorous in the tropics as elsewhere.

There was some reason for the old notion that the tropics are dangerous. For many years British firms offered comparatively large salaries to young clerks to go out to West Africa as "factory" bosses in the palm oil and kernel trade. The inexperienced and rather "below average" young fellow landed somehow through that almost ceaseless surf, was shown his billet, or post, and, worried and frightened at the strange sights,—as if he were shot onto another planet —he tried to find himself. He was confronted with coarse heavy food, no good drinking water, trade gin and cheap whiskey flowing all around him, bad moral ambient, and a terrible homesickness. There were mosquitoes of course, and malaria and black-water fever as the consequence, both natives and his few white associates going down and "going west", as the ancient Egyptians expressed it. To get any sleep in a noisome, musty, hot room, humming with

mosquitoes—and no bed-nets in those days—he quite excusably "drank up" till consciousness was lost. If he lasted ten or twelve months he might be sent back home, to spread the news as to how bad the tropics actually are; he at least had time to write back cursing the climate. Wherefore there began, seventy-five or one hundred years ago, the anathema against the tropics.

Thousands of those poor fellows lost their lives needlessly. Today, while morals and hygiene are not perfect anywhere, the selfsame country, which was reputed to kill a white man within the year, is healthful; the reeking "factories" are replaced with modern buildings in which a man can live very comfortably with his family. Now it is known that it was ignorance, not the climate, that killed. Much is still to be learned, of course, but the dangers even of a Guinea coast swamp can be overcome. Today convalescent patients are sent from the United States to a region where Chagres and yellow fevers, fifty years ago, took toll of thousands. No country has a lower death-rate now than the Canal Zone, yet Panama is known to have over 130 kinds of mosquitoes.

Some data relative to living in the tropics are here offered. The house must not be built on top of a hill. To catch the breeze, it may be set up on the slope; but, for some rather abstruse reason, the occupants of hill-top houses are seldom in good health. Except in very dry regions, the living-rooms should be six to ten feet above the ground; the under part may be used for storage.

Screening the doors and windows is not necessary though this plan has worked out very well in the Canal Zone for years. A good compromise is the screening of one room, on the balcony, preferably, to be used as a reading-room. Not only the most dangerous of all wild animals, the mosquito, but also other night-fliers, like termites and moths, are easily kept out provided the screening is in good repair and the door managed skillfully. In very pestiferous localities a door-trap may be necessary, a screened box

around the door with a sprayer handy therein to spray any mosquitoes which might get past the first door.

One of the most difficult problems of labor-housing is the reduction of the mosquito annoyance. Since in most countries the laborers prefer to shut all their doors and windows at night, a large proportion outside of Malaya sleeping without mosquito-nets, a good smudging just before shutting up is recommended. This drives out most of the insects, or stupefies them for hours. If the house is properly built up three feet or so on concrete or hardwood posts and if the floor is loosely laid (of split bamboo or palm slabs), the smoke-fire may be made right on the ground, a few handfuls of damp leaves or grass on a few coals, and there is less suffering from malaria and perhaps less filariasis and dengué, to say nothing of loss of blood.

Yet, despite the tremendous infant mortality and the ravages of malaria, hookworm, and other pests, the peoples of the tropical colonies and dependencies have in the last sixty years added 105,000,000 to their numbers, some 8 per cent of the then world population.

CONTROL OF MOSQUITOES

In nearly every hut in nearly every kraal from Tanganyika to Liberia, from Pará to Acre, and from Samoa to Bombay, the smudge is the simple, cheap, and effective means of repelling mosquitoes and sand-flies, of which there are several types, some even attacking at night and readily penetrating the mosquito-net unless it is made of cheese-cloth or muslin. (The writer had to use calico to stop the swarms of "no-see-'ems" in the Volcan de Tuxtla district of southern Mexico.) There are several kinds of smoke pastiles for mosquitoes now on the market. Pyrethrum powder appears to be the basis of the better sorts, such as the "Obat Nyamok" (Malay for mosquito remedy) of the Orient. In fact, ordinary insect powder makes a very good mosquito and sand-fly repeller. A spoonful piled in a heap on a tin and started with a match will afford

relief for an hour or so, properly placed under the dining- or reading-table.

When the smudge method is not desired, anti-mosquito oils or ointments are recommended for the hands and face and mosquito-boots of thick cloth to protect the ankles; in British Malaya loose feet-bags are used, especially by women.

Theoretically, every room, wherever and whenever the temperature is above 40° F., may contain one or more mosquitoes.

Protection against mosquitoes is one of the most important sanitary engineering problems of the world; but this applies to Alaska and the Gulf states as well as the tropics. Prevention, when possible, is greatly to be striven for. One of the most astounding features of living in mosquito-infested countries is the execrable neglect of, or indifference to, the routine of preventing the breeding of these pests. Intelligent persons who know full well the basic facts about the matter, very commonly allow these insect enemies to breed in eave-gutters, tanks, barrels, and pools around the house.

The Anopheles is really a domesticated pest; it follows the rain-water barrel; wherever man goes, he takes his malaria-carrier along too. Back in the heart of the jungle one can find plenty of mosquitoes breeding in the leaf-bases of bromeliads if no surface water is available, but not the kind that pumps Plasmodium into the blood-stream. These germs are so small that they cause no swelling of the salivary glands of the mosquito, yet mingled with the spittle, passing down the proboscis and purposely or accidentally poured out into the capillaries, they cause, it is supposed, a thinning of the plasma. A few of those germs caught up in the drift of the human's life fluid and burrowing into a corpuscle like weevils into a biscuit, finally multiply into billions, destroying a considerable percentage of the erythrocytes, the poison from whose break-up in the blood-stream demoralizes the nerve ganglia, causing ague, fever, weak-

ness, death; death, indirectly, perhaps, to many millions in the last thousand centuries. Without that disease the tropics would have been "settled up" long ago.

H. Hamel Smith [1] has put the matter very clearly: "We (in the temperate zones) cannot do without the foodstuffs and raw material which the hotter countries alone can supply. Were those supplies to cease, our population must shrink by 50 per cent, at least, and perhaps more, and the world would be held up because production in, and consequently trade with, the tropics would be checked owing to the lack of labour. And to-day, what amounts to the same thing is that the low output and high costs of what we are receiving owing to the indifferent health and heavy infant mortality, on account of chronic malaria, and other causes arising from this trouble, result in a great waste of lives and a reduced output from those who manage to survive."

Mosquito control is one of the important factors in the management of every tropical estate. The drainage or filling of breeding pools is expensive but it is permanent, whereas oiling is not. Ditches must be kept clean. All containers, barrels, tanks, and cisterns, must be screened or covered. Coconut half-shells and empty tin cans can harbor enough Anopheles larvæ to infect the whole neighborhood.

Potassium permanganate is recommended for killing larvæ in containers when kerosene would be objectionable. It also oxidizes all organic matter in solution. Its "sweetening" effect on drinking water, however, is not to be relied upon, and it is a poison.

CONTROL OF OTHER INSECTS

Ants are bothersome, but only one type is dangerous—the "army," or "hunting," ant. Many sorts get into foodstuffs but the army ant can drive man out unless one is quick with sprays or kerosene. The armies, however, leave a house free from roaches, spiders, and even lizards; fowls

[1] Smith, H. Hamel, Tropical Life, Apr., 1926.

if shut in are killed; the raid may come at any hour of the day or night, and it may last an hour. Fortunately the army ant is rare near dwellings; only once in twenty-eight years has the writer been invaded, and the army had to retreat with the morale of even the big-jawed "soldiers," or line guards, broken by sprays Bichloride of mercury is one of the best remedies against ants. Tape dipped in the strong solution, and tied about the legs of tables or food-safes, is the simplest and cheapest method, and even in damp localities it retains its ant-repelling property for months. Keeping food-safe legs in tins with kerosene is old-fashioned but quite effectual.

Termites are terrible. The subtlest of all house pests, their destructive work is not noticeable till far advanced. Extermination, with arsenic vapor or cyanogen, is possible but difficult. Fumigator pumps with special nozzles blow the poison into the nest and along the galleries. Calcium cyanide preparations are recently in wide use. Either concrete or hardwood posts should support the living quarters; in badly infested districts daily inspection (of the pillars, walls, and posts) for the tell-tale galleries should be made, and this applies just as well to Burma as to Nigeria or Surinam. Creosoted timbers are free from white ant attacks, if thoroughly treated. One sort destroys books.

Centipedes can give unpleasant stings, but they are rare except in very humid localities. Tarantulas are bad only in tropical America. Scorpions are really dangerous only in the Mexican mesa; the "Huero" actually kills children and individuals with weak hearts, and a bad sting in the dry season puts a terrific strain on the lymphatic system. Chigoes, or sand-fleas (*Pulex penetrans*) are serious in Central America and are spreading all over the tropics. Their burrow (usually in the foot) is clean and if properly treated with eucalyptus oil or any drying antiseptic and kept from infection, after removing the pea-size gravid female, no trouble results. Chiggers, or red-bugs, are the larval forms of several species of ticks, the life cycles of

most of which are still obscure; they are troublesome in the dry season in many countries. Kerosene rubbed on the skin before and after exposure—walking in grassy places near woods, especially—is a good deterrent.

Some ticks are rather dangerous, causing a slight swelling and discoloration around the bite, which sometimes sloughs out. Kerosene or any light oil applied direct induces them to "let go," though not very quickly; forcibly removing the body usually leaves the mandibles buried in the skin.

Leeches are troublesome in the wet season in some countries, fortunately not in many. Salt will poison them. Alcohol or any of the chemical salts, kerosene, and the like, make them break loose. The small wounds made by their cupping mouths should be dried up promptly with eucalyptus oil, borated talcum, or some antiseptic to prevent pus germs entering.

Human bot-flies, known as "mollacuiles" in southern Mexico, are decidedly annoying; the maggots seem to delight in nibbling nerve-ends half an inch beneath the surface of the skin. The larva is probably deposited on the body surface, back or shoulders commonly, and burrowing straight in, causes little trouble until it attains considerable size. The attempt to squeeze out the live larva is useless, but it is easily smothered or killed by working olive oil or any similar remedy into the narrow-orificed pocket. Chicle, the milky latex of the wild sapodilla, is recommended: one drop placed over the hole through which the mollacuil gets air suffocates the abominable pest in a few hours, and after a day it may be squeezed out, dead.

The hookworm (Ankylostoma) has for ages been a serious handicap in all warm climates. It slows down development by weakening the vitality of the laborer and his family. A dozen or so of these blood-sucking parasites in the digestive tract of an adult produces a tired feeling and a shortage of blood, not to say anæmia, which is a bad

negative factor. In a child this blood leakage, especially when coupled with malaria, produces a condition which frequently causes death and very commonly in many countries of both hemispheres seriously retards the growth of children of any and all the races.

The tse-tse (*Glossina morsitans*) is well named the biter; no other insect arouses such anger. It has decimated, almost exterminated, some tribes in central Africa. There are two or three drugs now, however, which if taken in time kill the trypanosomes in the blood-stream. Recently it has been learned that the viviparous female drops her larvæ onto the mud near water-ways, that it is probably parasitized, and that it is improbable that either antelopes or crocodiles act as necessary intermediary hosts. It is hoped that the sister species, *G. palpalis,* which transmits nagana to cattle and horses throughout most of the Dark Continent, will not transmit sleeping-sickness, as it has been suspected of doing.

Several obscure diseases in tropical America and Africa are caused by the bites of insects. Some of these germ-transmitting pests are parasitic on rodents or other vermin living in or near human dwellings.

Every large estate in the tropics—sugar-cane, rubber, or coconuts—requires a sanitary expert; his duty is to prevent rather than cure disease. In some cases he bears the title of malariologist. He should not be stinted.

DRINKING WATER

Drinking water is one of the prime factors in estate hygiene in the tropics. Generally speaking, rain-water is safest. It is nearly everywhere available. Even where the rains last only a few weeks, with properly constructed large-sized reservoirs fed by well-hung gutters from each side of the roof of every building on the premises, there should be no shortage unless the drought is much prolonged. The intake openings of these tanks should always have a coarse screen to catch leaves, and a fine one to bar

mosquitoes. The gutters must never be allowed to sag anywhere nor become clogged, otherwise Anopheles will start trouble.

In very dry regions it is sometimes advisable to construct a catchment area—a stone, concrete, mortar, or even clayed nearly water-tight floor laid perhaps on a near-by hillslope—leading into a conduit or surface gutter which conducts the rain-water into the storage reservoirs. Water caught in such ways is usually freer from germs than either well or surface water. The inside of the tanks should have a good coating of cement or mortar to prevent leakage; and inspection, once or twice a year, is advised; cracks in the inner wall may be puttied or painted over.

Cistern water may not taste as fresh as from the well or tap, but in districts removed from municipal water-systems —as in most tropical plantations—the prevention of contamination is very important if not vital. With thirteen different varieties of dysentery more or less prevalent throughout the whole archipelago, it is a marvel that any human being inhabits the Philippines, considering the fact that most of the water is drunk unboiled, and that springs even on mountain-tops are full of amœbæ.

There are several types of filters, some of which remove the pathogenic bacteria and even the "resting spores" of protozoa. Some work by gravity, some with hand-pumps.

Cheap stills are also employed when the water is actually muddy or very dangerous. The use of chemicals, such as potassium permanganate, is seldom warranted; the more or less irritant effect in the stomach must be considered, in cases in which filtering or boiling is impossible. Keeping water in copper vessels is undoubtedly a good prophylactic measure, and it has probably saved millions of lives in China; typhoid germs are weakened by even an infinitesimal trace of copper salts in the water.

Artesian water is becoming more common in both hemispheres. Being practically germ-free it has only one common fault, an overcharge of mineral salts, alkalies usually,

which are not always safe in the end, either for plants or animals.

Some attention has been given in recent years to the sanitation problems of the laborers' quarters. By strict observance of modern hygienic principles concerning water supply and septic tanks, much of the "illness waste" is now avoided. In the Orient in some regions and seasons as much as 30 per cent of the labor force is laid up; in firms, some of which employ as many as 20,000, even a 15 per cent sick-list is a heavy financial drain. A small hospital with its large and busy dispensary is in evidence on most of the best sugar and rubber estates in both hemispheres. Besides the actual saving in labor units there is a distinct morale betterment of no small import.

ELECTRIC EQUIPMENT

The modern estate house can have at very moderate cost an acetylene or small electric-light plant. The electric refrigerator is rapidly becoming popular, especially with American residents. Ice, made from boiled, filtered, or rain-water only, helps to overcome the prejudice against the ill-tasting water so deplorably common on tropical estates. Most persons do not drink enough water in the tropics.

The new type of windmill, with propeller-blade fans and an automatic governor to prevent racing, geared onto a small dynamo, which is connected in turn onto a storage battery, is bound to be one of the great items of tropical estate economy.

DIET FOR THE TROPICS

Generally speaking, there is a shortage of animal proteids in the dietary of most peoples in the tropics. Vegetable proteids are good, but there seems to be some potential property of animal protein, beyond its easy assimilability, which recommends it. Beans are excellent, but meat, occasionally, seems to increase the stamina if not the bodily

strength. Among primitive races there is probably always more or less hunger for three things: meat, sugar, and salt.

Starchy foods—rice, sweet potatoes, cassava, yams, in order of importance—are widely prevalent in both paleo- and neo-tropics. They comprise the bulk of the daily rations of nearly half a billion people. Rice, the staple food of half the human race, is far ahead of all other crops. At four cents a pound the cash value of the annual yield of this cereal is over $7,000,000,000. No one can even roughly estimate the value of the world's sweet potato crop. It is not much in evidence anywhere in the tropics, yet it is everywhere. With plenty of sweet potatoes, a little rice, coconuts (for the oil), and dried fish or meat, or some legume seed—gram, chick-pea, pigeon pea, beans of the multifarious types—a people can live comfortably and cheaply. The cost per capita of such a diet should not exceed ten cents a day, one-fourth of the average income (outside of China), and by increasing the proportion of sweet potatoes the cost can be cut down to about half the figure.

Fresh vegetables are recommended, but in the tropics they are usually remarkably scarce. They contain vitamins, now believed to be necessary to the bodily stamina. In this connection, however, it should be remembered that two of the world's healthiest races, the Esquimaux of the Arctic Circle and the Masai of Tanganyika, seldom eat anything but blubber, meat, blood, and milk. And in central Africa quite large communities exist very largely on plantains with now and then a monkey or a few bats.

Fruits should be consumed more widely. Out of the 500 or more edible fruits of the tropics, not fifty are in general cultivation and only about twenty really constitute a considerable part of the food of the masses. Of these the coconut, of course, comes first, then the musas (the 350 or more distinct kinds of bananas and plantains). The dates probably feed as many as the breadfruits and more than do the mangos. It is worthy to note that the mango is

really a food fruit, and many thousands of people subsist very largely or even entirely on it.

Every planter or dweller in the tropics can readily have at least six or eight fruits. They are coconut, banana, breadfruit, avocado, mango, orange, pineapple, and, when convenient, the soursop and the guava. Besides these almost indispensable fruits which can easily be grown almost anywhere below 3,000 feet elevation with 40 inches or more rainfall, the following should supplement: grapefruit, mandarin, lime (these three popular members of the citrus group are fortunately cultivable nearly everywhere, the mandarin being rather particular, however, as to its environment), papaya, malay-apple, tamarind, sweetsop, rambutan, lanzon, akee, sapodilla, pejibaye. Several species of Passiflora will grow in most places. In dry regions several kinds of tunas (Opuntia spp.) furnish juicy luscious fruits in abundance.

While many persons claim that they do not care for fruit, a large and growing number are not only strongly in favor of fruits in quantity but are epicures as regards qualities. There is occasionally noticeable a rivalry spirit, to see who can assemble the largest collection of first-class fruits. Nevertheless, taking tropical dwellers as a whole, they are deplorably indifferent about fruit- and vegetable-growing for their own convenience.

This inexcusable neglect to provide for the absolutely necessary varied diet is partly due to an old ingrown prejudice against avoidable work on tropical homesteads and partly due to a surprising ignorance. Some temperate zone vegetables do not thrive in the tropics; but that is no excuse for the average family's lack of variety of fresh vegetables in the latter zone. *Bacillus solanacearum* makes tomato-growing difficult but not impossible. Some types of lettuce cannot endure the tropical sun in the dry season. Celery and parsnips are hardly to be expected, but arracacha (*Arracacia xanthorrhiza*) combines good qualities of both and grows well almost everywhere, if given a fair chance.

Green salads are sadly lacking on tropical tables, yet a good variety is perfectly possible with a reasonable amount of care and attention. Young yautía (Xanthosoma spp.) leaves, sweet potato vine-tips, basella, mustard of the large-leaved sorts, chard, some types of collards and headless cabbages, string-beans and okra (which thrives remarkably well throughout the tropics) may be obtained in most places.

Meats are not so easy to procure, perhaps. Yet in nearly every tropical estate poultry and goats can be raised with little trouble. If protected from snakes and mongooses fowls succeed well. Chevon, the new official name of goat meat, is a very satisfactory source of animal protein; it is the cheapest meat available in both tropics. The common prejudice of the upper class against chevon is due largely to the odor of the old males, but when slaughtered before the age of five months there is practically no "taint" whatever, and if desexed (preferably by the simple modern vasocclusion method) the males may be allowed to reach full size. The goat is free from tuberculosis and trichina, one of the healthiest domesticated animals, but internal parasites in wet districts sometimes are very serious. Grass is not required; browsing on weeds and brush is preferred to the sweetest guinea-grass.

Sheep are not so healthy in the tropics, and they grow more slowly. Rabbits are the victims of many pests and germs; when these can be controlled by the zoötechnists of the future the tropical meat problem will be simpler. Healthy rabbits produce meat considerably faster than poultry and are more easily fed. Cavies are good but not popular.

Pigeons do very well when hawks are not too rapacious. Ducks are recommended where there is water and green feed.

Hydronomy will become one of the great branches of the future agriculture. In many countries, particularly in the Philippines, artificial ponds yield good profits in fish; half

a dozen species are raised with the same sort of management as poultry. Crushed kaong, or sugar palm (*Arenga saccharifera* or *A. pinnata*), pericarp pulp which is full of raphides like powdered glass, sprinkled around the margins of these fish ponds prevents night thievery by shoe-less poachers.

In many parts of the Orient the Chinese raise enormous numbers of ducks, using a special sort of duckweed for pasturage. The flock of ducks is moved from one pond, or fenced-off portion thereof, to another as fast as the succulent growth is consumed. Select strains of the weed will form a dense green mat over the surface in four or five weeks from sowing. Fish may be raised in the same pond and undoubtedly clams would thrive on the bottom. Thus in the three strata, mud, water and surface blanket, the art of getting meat for human food is shown in a light almost unknown in the Occident. Cheap sago, from any of the four or five species of palms with starchy piths, or cassava waste or millet may be given when necessary to eke out the duckweed diet. Offal from the ducks, if dressed on the premises, feeds those kinds of fish which require something besides the plant growths. Carp-like species are purely herbivorous.

Very fine and large oysters abound in the Junk River, Liberia.

In many regions of tropical America the manatee furnishes most excellent meat by the half ton to inhabitants along rivers, lake-shores, and the sea-shore. The adult "mermaid" weighs from about 800 to 1,500 pounds. About one-third of the carcass may be salted or smoked or dried. The white pork-like meat from the forequarters and the red beefsteak-like flesh from the pelvic region are excelled only by hippo meat—the famous "zeekoe spek"[1] which the Boers relied on in the days when they were civilizing southern Africa. Manatee should be introduced into every

[1] Sea-cow bacon. One two-ton animal furnishes about 500 pounds of dry biltong.

body of water where there is sufficient forage. They can live entirely on sea-weed or guinea-grass which grows along the margins of most bodies of fresh water in Central and South America, the culms pushing out onto the water two or three yards from the bank. Gatun Lake in the Canal Zone should support thousands of these valuable food animals; exceedingly timid and stupid, they are perhaps the most inoffensive of all the large mammals. Hippopotami have been suggested for stocking Gatun Lake, and they might succeed there; but they require more than grass, and a cow with her young one is at times far from being inoffensive—to persons as well as maize fields.

Fresh-water tortoises, some herbivorous and some piscivorous, may be raised in fenced-in ponds. For fine flavor their flesh is unsurpassed by any beast, fowl or fish. Many species of frogs are well worth raising for meat.

Apiculture is one of the oldest branches of agriculture. Honey by the thousand tons is exported from tropical American countries to the north temperate zone. It helps to keep bakery products fresh, being hygroscopic and nonfermentative. Bees should be kept on every citrus estate, coconut grove, and oil palm plantation. Adequate pollination may easily prevent some of the dreaded abscission. Honey is an excellent food for the tropical table, whether it is brown and strong from logwood chaparrals or amber-white and mild from orange orchards. Crystallized solid or left liquid as it flows from the centrifuge extractor, it keeps remarkably well, a year or even two if protected from the air.

Hundreds of tons of locusts are annually used for human food in those countries afflicted with the migratory swarm species. One non-swarming wingless kind (*Sphenarium barrettii*) of south-central Mexico is an ideal food insect, one of the cleanest of all animal species eaten by the human races. It feeds on only the freshest, tender, aromatic leaves of a wild shrub. The firm white muscles of the thorax, put through boiling water and then roasted or parched over a

slow fire with a little salt, taste like shrimps and are far more wholesome. Locust meal and dried locusts are excellent poultry and stock feeds.

In various localities, especially in central and northern South America and the Antilles, the large white larvæ of weevils (Rhynchophorus or Rhina spp.) which burrow in the starchy pith of various palms, and a fat caterpillar which lives in the hearts of the agaves, are recommended as excellent and perfectly wholesome delicacies for the planter's table. "Pickled" in salted vinegar for a few hours and then fried in coconut oil, these "gru-grus" surpass in flavor the mud-eating shell-fish so popular in the North.

Piquant spices are recommended for tropical cooking. There seems to be a sound basis for the nearly ubiquitous custom of highly seasoning the food in the warm climates; it is not so much for "stimulating the liver," however, as for "toning up" the digestive tract. One can imagine the fate of amœbæ coming in contact with ginger, nutmeg, or capsicum. Natives of India and Mexico commonly use forms of cayenne pepper strong enough nearly to kill an individual unaccustomed thereto. Even the "devil pepper," much more pungent than the Tabasco sort, is triturated with salt and eaten on rice "to awaken the stomach."

CHAPTER IV

COFFEE

Only about one-third of the inhabitants of the world use coffee. More individuals drink tea. Coffee is a comparatively expensive drink; most of the higher strata of the human race look on it as an important item in the day's mênu. Kola is decidedly more invigorating as 40,000,000 Africans would testify. Yerba maté, used daily by 30,000,000 inhabitants in South America is a clearer perhaps safer drink. The Arab insists that his delicious khat is better for nerves and muscles. The Amerind tribes of central South America rely on their marvelous guaraná, three times richer in caffein than coffee. Cacao, even in its abbreviated edition, cocoa, is nearly as stimulating and is a high-class delicious food as well as drink, and much appreciated by 300,000,000 people in Europe and the New World.

Coffee costs the staggering sum of over $500,000,000 a year. The world's crop is estimated at well over 24,000,000 bags—nearly 3,000,000,000 pounds; at the modest price (in recent years) of 20 cents a pound the value works out at nearly $600,000,000.

Coffee is the seed of a shrub belonging to the Rubiaceæ, or Madder Family, a group of herbs, shrubs, and trees largely confined to the tropics. The genus Coffea has some twenty-five species. A dozen or so produce merchantable seeds with stimulation from the more or less beneficent drug, caffein; but *Coffea arabica* in its many varieties turns out a good 90 per cent of the total seed in the trade. A rather well-behaved plant is the Arabian coffee; like most shrubs and trees it has certain idiosyncrasies when one comes to know it intimately—such as its flair for flowering

four or five times a season, every bush in the district covering itself with the fragrant snow-white bloom, concertedly; it is also particular about the setting of the fruit, and about shade and altitude.

ORIGIN OF COFFEE

There is good reason to think that Arabia obtained coffee from Abyssinia, probably about the beginning of the sixteenth century; and if the fifteenth-century record in Abyssinia is reliable, coffee has been in use there "from time immemorial." Several species of Coffea grow wild along the mountain ranges from Abyssinia to central Mozambique and over into Madagascar. Several tribes inhabiting that region, the Gallas in particular, have for ages been accustomed to prepare a war or travel ration, using the whole roasted berries of the wild coffee shrubs as the basal ingredient to which tallow is added; this ground to a paste while hot is made up into pellets, concentrated food tablets.

There are many entertaining legends concerning coffee. The delightful story of the bouncing goats, however, overlooks the real strong point: the legendary goats did not browse on the coffee "cherries," thus revealing to the astute goatherd the source of their "pep"; they must have eaten the leaves, very sensibly, too, since the leaf is actually richer in caffein than the berry. Perhaps before Queen Balkis of Sheba visited King Solomon, the aforementioned herder had stayed his hunger and thirst out in the goat pasture by brewing himself a pot of stimulating coffee-leaf tea. It is a mystery how they first discovered that by roasting and then boiling the seeds there could be obtained one of the best brews the world has found this far.

Early in the seventeenth century coffee reached the eastern Mediterranean countries by way of Egypt and the Holy Land. The Turkish quartermasters rationed it to the army besieging Vienna, notwithstanding its prohibition by the Koran as an intoxicating drink, and when they had to evacuate some 100 sacks were left in camp. A Polish

PLATE III.—A vigorous young Arabian coffee tree in full crop.

spy, so history relates, recognized the seeds, took them as his share of the Turks' leavings and promptly opened the first "coffee-house" in that part of the world. London, however, had a coffee-house as early as 1652.

About 1716 an officer in the French Navy took a plant or two to Martinique; from thence it reached Haiti, and a little later Porto Rico. From south Arabia it had gone, some 225 years ago, to Java; from there to Amsterdam, then over to Surinam. Brazil did not begin its cultivation till 1774, a century and a half ago.

The etymology of the name of this crop is confused. By rights, perhaps, it should be called "bunchum," the name given by the two first Arab writers, Rhazes (about 900 A.D.) and Avicenna (about 1000 A.D.). The latter scholar, alchemist, physician, and epicure gave a good account of this bunchum beverage. The English word is derived from Turkish: the Arabs sold the makings of the cup that cheers to the Turks as qahwe or qahwa, which meant a drink, but the latter began calling it kahveh and coffa; finally the Venetians and others spelled it cavee; but the first appearance of the word, (in 1598) according to Ukers, was written chaoua, the meaning of which is obscure. Unfortunately there appears to be little reason for deriving coffee from Kaffa, a district of Abyssinia where coffee was grown and whence the Arabs probably obtained it.

ECONOMIC STATUS OF COFFEE

The people of the United States are not the greatest coffee drinkers in the world, but each individual consumes nearly or quite a pound a month. The Scandinavians surpass America. On the other hand, the British peoples, wherever they may be, do not regard coffee in the same class with tea, using only about one pound per capita a year, while the Hollander and the Afrikander take nearly fifteen times as much. The extremely high prices obtaining in the past few years have tended to reduce the consumption somewhat; and the parlous predicament of the

Brazilian coffee trade has been causing much anxiety among the commercial coffee centers for several years.

The Turks are reputed to eat their coffee. As a matter of fact, there are others who prepare a very delightful mixture of sugar and coffee grounds and it is strange that this is not much more widely known.

In Sumatra the leaves are steeped to make a strange-tasting but very potent tea, which merely lacks the aroma of the roasted berry. Coffee-leaf tea is not astringent nor bitter, as would be expected, but a wholesome flavory beverage.

There is a double reason for the intense popularity of coffee: first, obviously, the caffein, which runs from about ¾ to 1½ per cent of the dry berry; and the coffeone, or aromatic oil, which in some mysterious manner develops during the roasting, and delights the nostrils. Roasting also liberates some of the caffein from the acrid caffetannic acid of the green berry.

The seeds swell up fully a third in bulk in roasting, but lose a heavy percentage in weight, about 16. For a hundredweight of roasted "bean," 117 pounds of the "green" or 138 pounds of the "parchment," or 550 pounds of the "cherries" are required.

Storing the "bean," as called in the trade, slightly increases the coffeone-forming quality, which directly affects the price. In Liberia the civilized natives claim that the local product (of *C. liberica*) is not fit to use till it has been kept a year in the "cherry."

All good things have imitations. In central and south Europe adulterants and substitutes[1] of coffee are excessively common. They may be harmless and they certainly are much cheaper.

The world has not yet gone very far in the way of beverages. There are hundreds of species of plants whose

[1]England imports some 5,000 tons of chicory root, and France uses probably thrice that amount annually; Spain and Italy also use vast quantities of this "garden coffee."

leaves, seeds, barks, and other parts contain a remarkable array of properties beneficial or pleasing. The study of such products is of surpassing interest. The preparation, however, of the material in exportable form is often very difficult. The excessive humidity in many parts of the tropics militates against the proper drying and packing of the raw material. If some kind of sun-dryer, with black metal sheets to catch and reflect the sun's rays onto the rack or tray holding the substance to be dried, were in every tropical farmer's hands the world would take a big stride forward, old products would be cheaper and new ones would come onto the stage. Moreover, this would lower the price of coffee, as quite a percentage of the crop on small estates is dried in the pulp, and molds almost always severely attack the cherries long before drying is completed.

CULTIVATION OF COFFEE

The kind of coffee to be considered in a brief discussion like this is, of course, the Arabian. The Liberian, the Excelsa, and the Robusta are merely larger coarser sorts of practically the same habits and cultivation.

There is a strong belief that coffee prefers elevations of 1,000 to 5,000 feet. Coffee cannot well endure drought, but revels in frequent showers and cool dews, and mountain slopes receive more precipitation than do the lowland plains. The best coffee grows in the rich forest humus soil at the foot of a high mountain, where the proper amount of shade protects the shallow-running roots from the direct rays of the sun.

The larger part of the world's coffee is grown on slopes and tablelands from 2,000 to 4,000 feet above sea-level. Most of the estates are red clay, cold, heavy, hard, frequently too shallow and too rocky for any other crop. Sometimes a planter actually makes some attempt at terracing, to avoid some of the down-hill "wash" where rains are heavy; but usually the humus blanket, the rich natural

soil which all forest growths delight in, is conspicuously absent, resulting in poor yields.

Plump ripe brown-red berries should be selected from healthy bushes, those that bend over under the weight of fruit. These seeds should be de-pulped, washed if convenient, and dried in the shade, since sunlight weakens most fruit seeds. They are then planted, say, 6 inches apart, in beds of light rich soil, slightly raised and well shaded; a canopy of banana or palm leaves will suffice. While the seedlings are developing, six to ten months, the "finca" should be prepared. All non-leguminous trees should be cut out and bananas or quick-growing legumes, not too large species, planted, unless the plantation is up 3,000 to 5,000 feet where no shade is required. Depending on the species and elevation, the shade trees may be set 30 x 30 or 40 x 40 feet.

According to the lay of the land, the holes should be 6 to 9 feet apart, 500 to 1,000 to the acre; 700 is a favorite number. In some West Indian "fincas" trees may be only 3 or 4 feet apart, whereas in some South American estates 10 or even 12 feet may be noted. Most coffee plants never get a good start; a few blows with a pick or mattock make the usual hole, but there should be at least a cubic foot of the top soil filled loosely into the hole before the young plant is set. In wet districts seeds may be planted in these holes, or very young seedlings set, but most planters in tropical America like to see the first side branches starting before they remove the plants from the seed-bed or, if they have been transplanted once, the nursery. Outside of Brazil most coffee plants are set out as volunteers, merely pulled from under the mother bush where they have fallen and germinated naturally; such plants usually live and do as well as could be expected in such circumstances.

A little attention is necessary two or three times a year to keep weeds from crowding the young tree. Many millions of coffee trees from Venezuela to Mexico have never been given a hoeing of any kind, the old machete

being the only cultivating tool on the average hacienda. Even on the big Brazilian fazendas the weeding and cleaning is done almost entirely with the cutlass. Vertical forking[1] is recommended for heavy clay soils in the rainy seasons.

In two years the new plants, if well started and encouraged, should throw their first bloom and, if it happens to set, seven or eight months later, the first berries will appear. However, this seldom happens; three or even five years may easily pass before the planter finds a crop worth picking.

By the fifth year, or possibly earlier, the young tree should be topped back to make more side branches; if grown without shade less pruning is necessary. In the open, in good soil, an Arabian tree may run up to 20 feet or more in as many years; a Liberian may exceed 30. Top-heaviness or loppy branches and vertical water-sprouts are ruthlessly slashed back into shape by the trusty machete. Small lush side sprouts are better pulled off than cut. Prunings and weeds should be thrown up around the base of the tree. In Spanish America, one, two, or three cleanings a year are given, depending, to some extent, on the profitableness of the business at that time and place.

After reaching a convenient height for hand-picking (without ladders), say 8 to 10 feet, the trees are kept there, by slashing, for many years, the trunk slowly thickening and bundling out till there may be three to five stems connected at the root. Brazilian unshaded bushes often stand 15 feet high by 10 or 12 feet in diameter.

Thirty years is supposed to be the average life of a coffee tree or, rather, of a profitable grove; individual plants might well pass two score and ten. Rarely a plantation is renewed by cutting back the old stems near the ground and letting one or two new stems shoot up quickly from the old roots. This should be done gradually, for obvious reasons, not to stop the crop all at once.

[1] See Chapter V.

The yield of coffee is a very variable quantum. Two hundredweight is perhaps the minimum normal average in tropical America. Many orchards produce hardly enough to pay for the picking, due to too much shade, too little pruning and cultivation, and to very poor soil conditions. Some old trees in Brazil have yielded at the rate of 15 pounds a tree for years on end. An acre of Arabian coffee in medium soil moderately well cared for should yield 500 to 700 pounds of dry beans.

Recent experiments [1] seem to indicate that young coffee, at least, is benefited by potash. An application of 300 pounds or more to the acre of a fertilizer composed of equal parts of sulfate of potash and sulfate of ammonia should give good results.

Coffee can be budded, at least in theory. If there were coffee research stations, some practicable method might be found whereby sprigs from a superior sort of Arabian could be grafted onto a Robusta root-system, perhaps, which might well increase the yield an acre (of Arabian "bean") five-fold or more.

Vertical shoots will sometimes root if planted, but not the laterals.

As previously mentioned, there may be two to five blooms, or sudden bursts of flowering, every season. No one knows the disposing factors which, over perhaps many square miles, force open at the same moment every flower-bud on every plant, old, young, vigorous, weak, in that section; a day, maybe, or a week or two later all the plants in the adjoining districts take their turn. Weather seems to have no direct effect on these flower explosions; yet, of course, there must be some subtle phenological factors working behind the scenes: the mystery is, how all the plants do it at the same hour. Incidentally, it is one of the prettiest sights in all tropical agronomy.

Some fruits may set from the first bloom; three blooms

[1] McClelland, T. B., "Experiments with Fertilizers for Coffee in Porto Rico." Porto Rico Agr. Exp. Sta., Bull. 31, 1926.

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may appear and every flower drop; yet the fourth or fifth bloom may set all the fruit the trees can possibly carry. Seven, perhaps eight, months from the setting, the berry, or, correctly speaking, the two-seeded drupe, turns to pink, then reddish, and finally a purplish or brownish-red. At this stage the wind or a slight shaking detaches the ripe drupes and results in a deplorable loss in all countries except Brazil; once on the ground they are lost, unless the picker is young and is working by piece-work, so many cents a basket or kilo or quintal.

HARVESTING AND MARKETING COFFEE

From September to January, from Venezuela to Mexico, the picking of coffee takes place. In Brazil and Colombia there are practically two seasons.

Men, women and children clamber up and down steep slopes, the baskets slung on a strap or cord over the shoulder; reaching, straining, slipping, sliding in Spanish America, Ceylon, and Java. In Brazil there is another way, as there is neither time nor necessity to bend down every branch, two, three, or four times in the season. There the plantations are of large trees, no shade, and clean level ground. The ripe berries are shaken, beaten, or pulled off, either onto the ground or onto mats or sacking carpets, then scooped up, the rubbish sifted out and dumped into boxes, barrels, carts or any receptacle to haul the raw product down to the pulping and drying plant. In some estates the berries are flumed down in canals, flumes, or pipes, a very material saving in transportation.

Then machines take up the work. In the small fincas there are still thousands of hand-pulpers. One or two men turn the cylinder which tears the fruits apart, the pulp falling into one spout and the seeds into another. A few hundredweight an hour are cared for by this old method, still extremely common. The big power mills on the large estates can de-pulp tons an hour. Water is run into the big hoppers to keep the sticky sarcocarp from clogging the short dull

teeth on the rapidly revolving cylinder. The seeds, covered with the sweet mucilaginous stuff, are run into huge tanks with only a little water; and there they stay, stirred from time to time, for twenty-four to forty-eight hours to ferment off the vestiges of the pulp. Tons of sugar are wasted thereby, but many more tons are lost in the pulp and skins which accumulate in vast heaps. Some way should be found to utilize both the sucrose content and the pulp itself, which ought to be good as cattle feed or something similar.

The seeds, after the so-called fermenting process is completed, are washed and then, in their clean, horny, pale dull yellow parchment coats they go to drying floors or possibly to some form of hot-air dryer. In the dry season, with good clear sun, beans should be dry in three to five days, if they are raked over frequently and well protected from dew and damaging showers. The artificial-heat apparatus, with trays or revolving cylinder or drum, may take the place of the broad "barbecue" with stone, brick, or concrete floor. The trays can be run out on tracks and, in case of danger from a sudden rain or at night, can be run back in under a shed roof, the tracks so arranged that the trays store in tiers, three to five or more, one above the other, in the tray house. It is a joyful sound to the dryer boss when the beans begin to purr and finally rattle as the peons shove and draw them about so that each seed gets its share of sun. Fortunately, the loose-fitting parchment shell inclosing the seed is nearly mold-proof; this is a great factor in drying, as there is no sticking together, no caking in lumps, as in the case of cacao.

The next steps in the process are to break out the real seed from the parchment coat, or endocarp, and then polish off the fine flaky "silverskin," or inner covering. The hand mortar and pestle can break the tough outer coat, which splits into two or more pieces, at the rate of a few pounds an hour. This is still practiced widely. The great de-hulling machines, or "tahonas," consist of two steel-rimmed wheels on a horizontal axle, about 8 feet long, whirled by a vertical shaft, running rapidly around over the beans

in a circular trough. Half an hour or so of this treatment and the charge, several hundredweight, is run into a winnowing mill which fans out the hulls and passes the seeds, now shining blue-gray in their tight-fitting silver coats, over to a second polishing machine. Here wheels, similar to the de-hulling ones, race around over a splashing bed of slippery beans, the side walls boarded up high to hold in the flying seeds, each one slipping and sliding over those in contact with it every second or less as the relentless wheels roll over them.

The fine talc-like dust from the rubbed off silverskin is nearly always wasted. The Porto Rico Insular Department of Agriculture and Labor, however, in 1924 proved that this fine powder could be used as a filler with molasses and fruit juices in cattle feeds, with tobacco extract in insecticides, and the like. Very unlike the parchment, it is quite digestible and contains 10 to 11 per cent of proteids, 35 per cent of carbohydrates, and 36 per cent of fiber. This material is wasted to the extent of many hundred tons per annum in the several large coffee regions.

The parchment goes to the furnace as fuel for running the mill. As a nearly pure cellulose, it should have a place in commerce despite its bulkiness. Occasionally, in some districts, a little talc powder and even a pinch of coloring matter may be thrown into the polishing mill, largely "to improve the feel and looks" of the bean when it reaches the buyers.

Coffee beans are packed in bags of 120 to 155 pounds, and shipped all over the world.

The profession of coffee blending rivals but does not surpass that of tea blending. Since nearly all the coffee now used either in family or restaurant kitchens is bought ground, the wholesaler has a chance to mix two, three or perhaps more kinds of beans (before or after roasting). The experienced blender working with an expert taster can easily prepare a recipe-like schedule: say five bags of "common or garden" "Rio No. 9," three bags of high-grade Salvador mountain bean, and one bag of rare exotic-

flavored Robusta from Java: roast each separately, of course; cool, mix all together, then grind and put up in cartons, tins, or drums immediately to avoid losing the volatile coffeone, or so-called coffee-oil aroma.

In the roasting, coffee loses weight seriously. On the other hand, like many other seeds when strongly heated, coffee increases a fourth to nearly a half in bulk in the oven cylinders. Many strange processes occur during the roasting; the proteids polymerize, more or less; oils change, tannin-like substances break up. No chemist would dare attempt to specify all the changes which occur between the dull gray-blue or olive-colored raw bean, which has lain around warehouses for a year or more, and the fragrant toasted seed. A few degrees too much, and the caffein "kick" or stimulus is burnt up; a little too cool, and there is a bitter tangy taste. No two kinds of beans require the same roast; the heavy burn for the sharp strong "Yaucono" of Porto Rico would kill the fine flavor of Hawaiian "Kona."

For many years the grower got from 7 to 12 cents a pound for the raw beans, while the retailer sold for three to four times that figure. There was no loss in storage and only about 19 per cent loss of weight in roasting; the middlemen, the roasters, the wholesalers, had a fair field and made fortunes. Speculation ran rampant. Then came, about 1906, attempts at valorization on the part of certain quasi-governmental agencies in Brazil. As the editor of *Tropical Life* puts it, "through an almost incredible change in certain basic conditions, the protective policies of São Paulo, which were at first largely speculative, have become really administration and banking matters."

COFFEE VARIETIES

The cultivated coffees may be grouped as follows:

1. The Arabians, comprising some fifteen varieties of three or four species (Plate III).

2. The Robusta group. which covers some four or five species.
3. The Liberia group of five species.
4. The Stenophylla species.
5. The hybrids.

Coffea arabica is a comparatively non-variable species. After some two centuries of cultivation in the neo-tropics there are in evidence hardly a dozen distinguishable forms and only two or three seed freaks. This is the smallest cultivated coffea, the height ranging from 8 feet or so in the Murta form to 25 feet in the Maragogipe. The berry is less firmly attached than in the other groups, a very important item.

The principal Arabian varieties are:

Bourbon, a famous American form of unknown origin.

Pointed Bourbon, a small variety discovered in Reunion.

Maragogipe, a coarse strong-growing sort discovered in the town of that name in Brazil. Opinions differ as to its real value. The yield is uncertain, the flavor high, and the harvest period late

San Ramon, a dwarf variety from San Salvador, with a very long crop period, August to January.

Mocha, a very small-seeded form, probably the original coffee which was cultivated more than 200 years ago in the regions of which Mocha was the seaport. Practically no bean is exported thence nowadays; in 1909 in Mozambique the writer obtained a half sack of the genuine article, but the odor of the unroasted seeds was quite disagreeable and the flavor of the cup very heavy. Brazilian Mocha is largely a trade name, it appears.

Columnaris and *Erecta* are mutations of the common Arabian, originated in Java. They are vegetative varieties of no great promise.

Harrar is an Abyssinian type.

Kona is the mild-flavored form grown extensively in Hawaii, some 3,500,000 to 4,000,000 pounds.

Murta is a dwarf late crop from Brazil, of little promise. It may be a hybrid.

The "pea-berry," or "caracolillo" beans are merely the seeds from one- instead of two-seeded fruits borne at the tips of the branches; their percentage runs from 5 to 8 per cent.

A multiple-seed form and a freak in which the seeds grow back-to-back have been noted in Porto Rico.

The Robusta coffees are large vigorous shrubs or small trees, with thick leaves, and with a tendency to bear heavily. The quality of the seed in the cup, however, is not good, and is usually blended with high-flavored varieties. They resist Hemileia and leaf-miners.

The true Robusta is native of the Congo Valley. It was introduced into Java in 1900, and by 1920 the acreage was about 300,000. This species is now one of the important crops of that island.

Quillou is becoming a famous variety. It is native to the French Congo. In Java it is reported to yield as high as 25 hundredweight to the acre.

C. canephora is a lusty form undergoing test.

C. Laurentii is another Congo Valley species of apparent merit, by many authorities considered a variety of *C. robusta.*

The Liberia group comprises several very large coffees, some reaching a height of 40 to 50 feet. The leaf is leathery, nearly immune to pests and diseases. The seed is very large, two to three times the weight of the Arabian, but the flavor is not pronounced, though the body is strong. Like the Robusta types of coffee the Liberias go into blends.

The true *C. liberica* is a West African tree, succeeding at sea-level without shade through the tropics. Twice as much Liberian (300 tons) as Arabian is produced now in British Guiana. Some of its hybrids may prove valuable. Even in Liberia its cultivation hardly pays, the main diffi-

culty being in picking and in keeping down the growth, as pruning is not well understood there.

C. excelsa is a handsome species discovered in 1905 near Lake Tchad by M. Chevalier, the great African explorer. Its fruiting season is perhaps the latest of all known coffees, March and April being the heaviest months in the Antilles. It ranks with Robusta as the best non-Arabian sort.

C. Dewevrei is another large Congo species. The leaves are 9 to 15 inches long, leathery, and shining. If this tree will endure continued pruning, it may become famous as a high yielder; or it may be used as a stock for forcing Arabian varieties.

C. Dybowskii has the largest leaves of any known Coffea —up to 20 inches in length by half that breadth. The cherries are very large, about 180 to the quart.

C. abeokutæ of West Africa resembles the typical *C. liberica.*

C. stenophylla is a very interesting species from the Sierra Leone. The plant somewhat resembles the Arabian, but the fruit is smaller and is borne in enormous quantities, closely set on the long slender side branches. The tree seems to have more vigor than the Arabian and the yield is claimed to be two or three times greater. It will probably become popular.

There are already quite a number of hybrid coffees under test, and their number will probably greatly increase. *Coffea ugandæ* is one of the better known hybrids; the individual plants vary in size and shape of the seed.

The "congensis" hybrids are being studied in several stations, Java and Porto Rico,[1] for example, and some may prove of high merit. It should be fairly easy to breed a new race of coffees having not only greater vigor but also more aroma and, if desirable, more caffein.

Along the east side of Africa there are several wild

[1] McClelland, T. B., "Coffee Varieties in Porto Rico." Porto Rico Agr. Exp. Sta., Bull. 30, 1924.

and semi-cultivated species of Coffea, *C. eugenioides* being typical. Some of them have an offensive aroma and but little or no real stimulating properties, yet they bear well without shade at sea-level. They merit study.

PESTS AND DISEASES OF COFFEE

All over the world coffee suffers from the usual number of crop enemies. One reduces its vigor by about 10 per cent which means that the yield is at least 15 per cent lower than normal. One threatens the plantations of the heaviest producing country.

Insects.

The coffee leaf-miner, *Leucoptera coffeella,* eats out the mesophyll between the upper and under cuticles of the leaf, leaving brownish patches, irregular in shape, ½ or ¾ inch in diameter. Many leaves show two to four of these blotches, each mine with its solitary yellowish larva feeding night and day. Fortunately this miner is partially kept in check by minute hymenopterous parasites. In 1904 the author discovered *Zagrammosoma multilineata* and *Chrysocharis livida* killing a very high percentage of the miner larvæ in Porto Rico; and since then Box [1] has found three parasites in Kenya, two have been discovered in Reunion, and two more in Brazil—a total of seven species which help keep down the yield of coffee. Cook states [2] that the leaf-miner causes a loss of 20 to 40 per cent of the foliage of coffee grown in Porto Rico, and 56½ per cent loss in Cuba. Mann [3] estimated that the coffee crop of Brazil was losing (in 1872?) no less than one-fifth annually through the agency of this terrible pest. However, these figures are much too high.

[1] Box, Harold E., "The Bionomics of the White Coffee-leaf Miner, *Leucoptera coffeella,* Guer., in Kenya Colony," Bull. Econ. Res., Vol. XIV, Pt. 2, 1923.

[2] Cook, M. T., "The Coffee Leaf-Miner (*L. coffeella,* Stain)," U. S. Dept. Agr., Bur. Ent., Bull. 52, 1905.

[3] Mann, B. P., "The White Coffee-leaf Miner," Amer. Naturalist, VI, pp. 332-340, 596-607, 1872.

The actual loss of crop in Porto Rico chargeable to Leucoptera infestation is probably not over 5 or at the most 10 per cent, and Brazil doubtless loses a much smaller amount. Nevertheless, this pest is virtually consuming some $10,000,000 to $20,000,000 worth of coffee every year, while presumably not even so many thousands have been spent by all producing countries in attempting to eradicate it. The matter is left to the parasites, the rains, dews, and shade. Tobacco extracts are effective in nurseries and seed-beds, but too expensive for field application.

There are several boring insects which enter the stem and larger branches and in some regions prevent the successful growing of coffee. *Apate francisca,* a small beetle, is one of the worst of those borers. A dozen or more of these pests may be found in burrows in the wood of one coffee bush. Cyanide preparations are recommended.

A burrowing ant, *Myrmelachista ambigua,* causes much damage in tropical America. Not only does this pest weaken the stem by its tunnels, but it also keeps mealy-bugs (such as *Pseudococcus citri*) in the galleries and from thence transplants colonies to the young shoots.

There is also a moth-borer, Psychonoctua sp., which burrows in the pith of young branches. A particle of some cyanide compound put into the opening would kill the larva.

A leaf-eating weevil, *Lachnopus coffeæ,* does considerable damage in some districts. Fortunately for Porto Rico it is there held in check by a Eulophid wasp one millimeter long, *Tetrastichus vaquitarum.*

Both brown and black aphids sometimes attack the young growth, causing rather serious damage. Nicotine dusts or sprays are costly but effectual.

Several scale insects are in rare instances injurious. The worst is *Saisettia hemisphærica,* a large red hemispherical Coccid of remarkable prolificness; its fungus parasite, *Cephalosporium lecanii,* does not check it to any extent.

Recently in Java, Surinam, and Brazil there have

appeared coffee-seed weevils, *Stephanoderes coffeæ* and others. These small beetles attack the green berry, eating into the seeds before they harden. No spray can reach them. A few wormy beans in a lot bring down the price very sharply. Three years ago it was estimated that 40,000,000 coffee trees in Brazil were infested with a species of this seed weevil. The outlook is bad. Removal and destruction of every berry before ripening, throughout the entire infested districts, over a twelve-month period, seems to be the only remedy.

Diseases.

Some forty-six species of fungi attack coffee in the old and new tropics. Fortunately at present very few of these organisms cause much loss.

The commonest fungus attacking coffee in the western hemisphere is the American coffee blight, *Stilbella flavida.* This fungus produces yellowish spots, about ½ inch in diameter, on leaves, twigs, and berries. Usually this disease causes only slight damage, but in some cases it may reduce the yield by one-half. Bordeaux is theoretically a remedy.

The Koleroga disease, *Corticium koleroga,* is probably present in every coffee district where shade is used. Thread-like strands of mycelia grow up the stems and out onto the leaves where they penetrate the cuticle and destroy the tissue. These threads are at first white but gradually turn brownish. The dead leaves remain attached by the tough mycelial strands. Twigs and berries are sometimes caught in the deadly cobweb net. The method of reproduction is not well understood; fortunately it appears weak.

There are several rare root diseases. One, *Hymenochæte noxia,* is giving trouble in the Orient. The American root-rots are not yet well known.

Several species of Cercospora attack both leaves and fruits, causing spot diseases. *C. coffeicola* is prevalent in all coffee regions, and it is really strange that it does not

spread more, especially in the over-shaded orchards of tropical America.

A mosaic has appeared in Surinam. Its physiology is unknown.

Fortunately coffee is nearly immune to the cankers which attack cacao and citrus so badly. *Ascospora coffeæ* is a xenoparasite (a parasite entering only through wounds) in Java. It quickly poisons the whole plant.

In the eighteen-eighties a terrible leaf-blight, *Hemileia vastatrix,* swept through the Orient, practically wiping out every plantation of Arabian coffee from Ceylon to the Philippines in the space of about ten years. It prevents the cultivation of this species on that side of the world still; no control measures are known. In 1903 a Wardian case containing some eighty dead and dying coffee seedlings was delivered at the newly established United States Agricultural Experiment Station, at Mayaguez, Porto Rico. Supposing some institution had donated these plants, the case was opened, but the Station immediately became suspicious of the appearance of the contents and very luckily took extraordinary precautions with the material, keeping six trees, burning the remainder and sending in to Washington for determination specimens of the infested leaves. In due course the identification was reported back as *Hemileia vastatrix.* If the wind had blown those spores toward a patch of coffee twenty yards away, or if formaldehyde and fire had not been used promptly it would almost certainly have repeated its Old World devastation.

OUTLOOK FOR THE COFFEE CROP

In some ways it looks as if coffee has already reached the saturation point. There was a falling-off of over 9 per cent in the United States imports in the 1925 calendar year, due partly to the high prices and partly to something like animadversion against the policy and practice of the Permanent Defense Institute of Brazil.

In the tea-drinking countries coffee consumption cannot

expand. In Europe the very high cost of coffee throws the trend toward cacao preparations and substitutes, such as chicory. There are no other large fields to conquer.

Brazil is producing, roughly, some three-fourths of the nearly 25,000,000 bags of raw coffee, and she can extend the area (some 3,500,000 acres) and increase the outturn considerably; she has the system and the experience. A few other countries can expand and will, if the high prices can be maintained.

Twenty-two countries in Africa are producing. Kenya is planting some 70,000 acres already. Toward 20,000 tons are now exported from Mombasa. Angola has vast stands of wild coffee. Colombia can turn out much more, and of the very choicest grades. The Central American bean is very high-grade but there is not much chance for any great expansion; Guatemala and Salvador lead. Java will continue to push the Robustas as far as the market will allow. Hawaii, Haiti, and Porto Rico export some excellent coffees but all their plantations combined could be lost in the vast area of Brazil.

Much of the future of coffee depends on what happens with the coffee-seed weevil in Brazil. If this pest should spread to the billion bushes in the state of São Paulo, or if the structure of the Defense Institute should collapse, the whole face of the industry will change. What would happen to prices no one can foretell. Cacao would greatly benefit, of course, and tea also.

Kola may take a prominent position among the beverages any day.

While there are difficulties in Brazil, the other countries are rejoicing in the excellent market for all their grades of bean. The American public can afford to pay the extra modicum and this cheering hiatus between cost of production and selling price puts new life into thousands of estates from Mexico to Demerara, and this plantation prosperity will be reflected in better trade relations.

CHAPTER V

CACAO

Cacao is in a class by itself as it is both a beverage and food crop. Coffee should be in the same category, but is not. Tea is virtually and financially twice as important as cacao, but in commerce and industry the reverse is true. Coffee is between three and four times heavier in trade and six or eight times more valuable.

Coffee costs by the pound, production-center price, about twice as much as cacao, and tea between two and three times as much, depending on where the value is calculated. Yet this cheaper commodity has not only about the same stimulating power as these two other beverages but in addition is a very nutritious food. The industrial world is fortunate in obtaining cacao so cheaply. Were it not for the disconcerting but comprehensible fact that in a single African colony native growers are today producing over half of the world's crop at about half the production cost a pound in other countries, the buyers would be paying not around ten cents (on an average) but probably over twenty cents a pound for the raw bean.

Cacao is one of the most interesting strictly tropical export crops. If its "butter," or fat, were a little more readily digestible, it would excel, perhaps, both coffee and tea. Chemists are obviating this negative feature by taking out the heavy fat and substituting one or more lighter ones—just as the factory manager covers up the bitter taste with sugar.

BOTANY AND ORIGIN OF CACAO

Three or four species of Theobroma produce cacao seeds; the sixteen or eighteen others are not used. All are tropical American in origin. Authorities differ as to whether they are all cultigens.

The family Sterculiaceæ has about 750 species; it is related to the Tea Family.

About 98 per cent of the crop is produced by *T. Cacao*. *T. pentagona* is cultivated in Nicaragua and adjoining republics. *T. speciosa* and *T. angustifolia* are unimportant. Of *T. Cacao* there are some twelve or fifteen distinct types, distinguishable largely by their fruits. These may be yellow or reddish, long or roundish, small or large, bottle-necked, ridged, smooth, and the seeds also differ in color and flavor.

Cacao is an ordinary-appearing tree, 15 to 25 feet high, with thin, fairly large leaves. The striking peculiarity is its habit of producing the very small pinkish flowers and fruits in clusters, on "buttons" on the trunk and larger branches; in fact, the fruits are so closely attached to these buttons that their removal without injury to the bark requires trained pickers. The beautiful pods, as the fruits are called, ripen at all seasons, though there is usually one large harvest and several minor pickings in the year. Inside the thick granular-woody shell there is a scanty white pulp, sweet and well flavored and cool tasting, and large irregular-shaped flattened seeds, twenty to forty or more, somewhat like large plump lima beans, of a beautiful lilac-purple shade inside, sometimes pink.

Cacao probably occurs in the wild state in the jungles of northern South America; at least very close relatives of it have been discovered there. Centuries before Colón (Columbus) came over searching for pepper and cinnamon at fifty dollars a pound, this denizen of the coastal rain forests had traveled perhaps from the Orinoco around up to the "Tierra Caliente" of eastern Mexico. The seeds dried and roasted and steeped, with or without other substances,

PLATE IV.—The cacao harvest. The knife on the bamboo pole is used for the higher "pods." *Inset:* typical "Forastero" fruits; one ripe.

like the seeds of the Ceiba tree, were consumed as a food-drink by the upper classes. Small bags of the seeds were used as money. Without milk and sugar, bitter and gritty, the Emperor Montezuma quaffed fifty mugfuls a day and gave 2,000 more to his household because, besides the nutritious fat, starch, and proteids, they got a 2 per cent caffein stimulus out of the theobromine. Most coffee has only about half as much of the similar alkaloid, caffein.

The Aztecs, who were unquestionably the first to use cacao largely, named it "cacaoquáhuitl." The Spaniards, having little respect in those days for aboriginal words, dropped the latter half. The British later transposed the letters.

Chocolate, the preparation of the ground seeds, was called by the Aztecs "chocolatl." The Spaniards were in that case content with substituting an "e" for the final "l"; and the English lexicographers divided it into three syllables and set the accent back on the first. The British grower insists on calling his cacao orchard a "cocoa walk." But correctly speaking cocoa is the flour left after taking most of the fat out of the ground seed, or chocolate.

The Spanish for coconut is "coco"; hence to avoid confusion in trade parlance, the Trinidad merchant sells "cokernuts" and cacao and buys Venezuelan cocos, and also local cocoas.

ECONOMIC STATUS OF CACAO

Few realize that cacao has recently been climbing to a very prominent place in the world's commerce. It is nearly half as large as coffee, over 500,000 tons. Since the perilous slump in price of the raw bean on account of the vast output of very cheap-grown stuff in the Gold Coast, the confectioners have profited: cynically speaking, 10-cent chocolate plus 5-cent sugar equals 80-cent candy.

If 3 pounds of 10-cent cacao are put through the mill, resulting in 2 pounds of cocoa powder worth, say 15 or 20 cents, and 1 pound of cocoa butter (the yellowish at first,

then white, fragrant rich vegetable tallow taken out of the hot ground semi-solid paste) worth, say 25 cents, there will be a gross profit of 35 per cent to 50 per cent for the factory.

The United States now imports about 425,000,000 pounds of cacao, or between three-sevenths and a half of the total production. The consumption in the confectionery trade is enormous and is increasing. All grades are used, but about 35 per cent comes from British West Africa, which produces about 225,000 tons, nearly half of the world's supply.

Brazil is producing heavily the past few years (since 1922) and has held rank as the second cacao country since the Great War. Ecuador is in danger of losing her place, in fact Nigeria is surpassing her already, and no one knows what Lagos will do later. Colombia and Venezuela could easily double their output. Trinidad and São Thomé, old rivals, keep an even status, 18,000 to 30,000 tons. Costa Rica, Santo Domingo, and Nicaragua should expand, for they have ideal cacao climate and soil.

Cacao, as a food-drink, is not sufficiently appreciated. It is much more stimulating than coffee, ounce for ounce, and a good rich food; the butter is indigestible if taken in large amounts. Plenty of vanilla and cinnamon is needed to spice up cocoa and chocolate as a beverage; the semi-solid preparation is made from the powder—not too poor in oil—boiled thoroughly in as small a quantity of water as possible, then a little cream, spice, and plenty of sugar.

CULTIVATION OF CACAO

Cacao likes heat and humidity better perhaps than any other crop; *i.e.*, it is a typical megatherm. Droughts it cannot well endure, nor elevations above 2,500 feet. It revels in red clay, probably because it holds moisture so well; but if this clay cracks under the strain of a long dry spell with no (almost indispensable) blanket of leaves, the roots suffer severely. Rich deep loamy alluvium along river banks is best, provided the valley is not exposed too much to the

wind; or up along winding streams back into the hills if the slopes are not too rocky.

Forking is a common practice in most tropical American cacao orchards. The old method was very destructive to the roots, though it did, of course, aerate the heavy soils. In Trinidad in 1907 a laborer was ordered to fetch a spade and demonstrate to the writer the then current style of forking: he came with the spade, but said he could not proceed till he had a cutlass to chop the roots. Consequently, the writer devised the vertical forking method: a short-handled fork with strong straight prongs is thrust (by hand and foot) vertically into the earth, not too close to the trunk base; the handle is then moved backward and forward till the tines are loosened in the soil, then taken out. These tine holes let the air down 6 or 8 inches beneath the surface, no roots are broken—no "chopping" is necessary —and these enlarged tine holes fill gradually with fine surface silt and humus particles, held right where the feeding roots can utilize them. Twenty to forty vertical thrusts in the root radius of a medium-sized tree allow the roots to get their due supply of air, even in heavy clay soils.

Deep drains are necessary wherever the least trace of stagnant water might be suspected.

Cacao is a noble crop and will not endure the slights and lack of attention so commonly shown coffee and coconuts. In Trinidad the old creole planters have a wise adage, to wit: "Old Mis' Cocoa, she likes 'e soun' o' de human voice"; and, true enough, within ear-shot of the hut the trees bear twice as much as those receiving less attention.

Seed should be taken, of course, from the best parent trees, those which always carry a good number of pods, and which produce good plump beans of the correct color and flavor. This is not so easy as it sounds, but cacao planters are ahead of coffee growers in starting their seed selection right.

Seeds may be planted "at stake" or in beds in a regular nursery or in bamboo pots or palm-leaf baskets. Under

favorable conditions, *i.e.*, where there is shade and plenty of rain, two or three seeds may be planted in the hill, the most vigorous one to be left *in situ* in due course. In starting a new grove, however, where the young seedling has to meet sun, wind, and weeds, perhaps, there is better chance of success if it goes out into the open-space dangers well prepared to win out. In the writer's experience the bamboo-joint, one seed to the pot, is the best method; germination is better, and the seedlings can be kept in the pots till they show six or eight leaves, but by that time the tap-root is creeping out of the hole in the septum at the bottom of the joint. When taken to the hole, which should have been dug deep and wide and nearly filled with surface soil, weeks before the transplanting, the pot is thrust down into the loose soil, then with a hatchet or short machete one side is split off carefully and lifted out, earth is pressed up against the exposed soil cylinder still intact in the remaining half of the pot which is then left, erect and solid-set. The holes may be 10 x 10 feet on slopes but in rich soil 12 x 12 or 12 x 15 feet is better. This means 300 down to 240 to the acre.

Shade is nearly always necessary. Cacao is by nature a jungle denizen and dislikes wind; in fact, strong winds at the time the flushes of tender new leaves occur at the tips of the branches may whip them to pieces in a few hours. Too much shade, however, conduces to fungous attacks of all kinds and thus to low yield. Several species of Erythrina, called Dadaps in the Orient and Bocares in the American tropics, are the favorite shade-producers. They have one exasperating fault: whenever their shade is most needed, during a long drought, they always shed every leaf, letting the sun down to the ground, cracking open the red clay and torturing the cacao roots.

To make the trunk branch out at the height of 3 feet, three or four main branches preferred, a little cautious pruning may be necessary the second year after transplanting (or planting at stake). Thereafter pruning is a fine art in

the cacao grove. Not only must the tree be kept balanced and open but the two sorts of vertical sprouts must be removed promptly, twice or thrice a year gone over by an expert with experience, a very sharp knife, saw, and paint-pot. One of these suckers has plenty of leaves and may be left to form a new trunk if the old one develops canker; the other water-sprout will shoot up 4 to 5 feet in a few months, with hardly any leaves, and will distract the tree's attention from fruit production unless promptly removed. The proper removal of cacao side-shoots is a very difficult pruning operation. They should be taken off carefully, close up to the parent trunk, without injuring the bark, and with the application of some thick bland paint or wound wax to promote quick healing-over of the scar.

HARVESTING CACAO PODS (PLATE IV)

The fourth or fifth year there should be a number of fruits. If any set the third year they should be removed to avoid lowering the young tree's vigor. From the fourth to the fortieth year the tree should bear two crops, one long and heavy and one a few months afterward more irregular and uncertain. A fruit cushion, or button, may produce four or even six pods almost simultaneously, so that their bases, crowded together on their one-inch peduncles, become squeezed out of shape. Cacao, when free from fungous pests, is almost too prolific.

Since by the tenth year some of the pods may be borne too high for the pickers to reach with the cutlass or shorter knife, there is on most estates a pole-picker—a triangular blade mounted on a handle 6 to 9 feet long. Some of these blades have on one side a down-curving prong with cutting edge, so that a downward pull will sever a pod on the upper side of a high cushion. Most pods are removed by upward jabs of the pole-knife, and probably one-third of these jabs cut into the bark of the cushion or wood near thereto. Knives nearly always carry germs of the black-pod rot (*Phytophthora faberi*), and therefore every cut is

an inoculation. A tarred rag, wrapped around the base of the blade, touched to the bark wound would prevent most of the trouble.

The pods drop to the ground. Unless weeds are unusually bad, the gatherers never miss a pod, red or yellow. To save bending over, a favorite trick of the gatherer is to thrust the point of the cutlass into the pod, then with a quick swing and recoil the pod is hurled 10 or 15 yards away to a pile which is later broken *in situ*, perhaps, or packed down by burro or mule (purposely bred very small to pass under the branches easily) to a general breaking ground.

Cacao picking is interesting work, requiring much more intelligence than coffee picking. The cacao pod shows certain indications of its maturity to those who know, but these signs can hardly be put into words and even the most intelligent experienced pickers cut many a pod that lacks a week or two of being fully ripe. Five to fifteen pods a tree at a picking is probably a fair average. Many fine old trees, 8 to 12 inches in diameter and 15 to 25 feet high, give less, while a vigorous young tree may yield twenty-five to seventy-five beautiful purple and orange fruits at one cut. About twenty pods are required to make a pound of dry seeds. From 300 to 500 pounds to the acre is the outturn: the average probably runs around 425 pounds.

The breaking is always an interesting task. Usually heaps of a few thousand pods, here and there near paths, are made in the shade. Two sharp short blows of the machete or heavy knife by an expert, three or four by the regular peon, breaks the semi-woody shell around its equator, disclosing the white pink-streaked mass of pulp and seeds, which is tossed in a pile for the women strippers. A good breaker will handle 500 or so pods an hour; but only a specially trained wrist can hold out all day without cutting either fingers or seeds. Stripping the seeds from the placental strings running lengthwise of the seed-pulp cylinder looks simple, but is a difficult operation. The seeds in their delicious but scanty ice-cream-like pulp are

shoveled into sacks, pannier baskets, or head baskets, and sent down to the fermenting boxes. The empty half-shells are left to rot usually right where they were broken. In a year the crumbled black mass may be flung about under the near-by trees to help out the blanket. A liberal dusting of lime over the heap, occasionally, hastens decay and lessens the number of mosquito larvæ in the up-turned shell halves.

CACAO FERMENTATION AND PREPARATION

When the seeds arrive at the "sweating room," the process is no longer agricultural but chemical. Much training and clear judgment is required in cacao fermentation. Much has been written regarding the proper temperature, size of bin or box, manner of mixing, duration, exposure to the air, but as no two batches are alike, no rules can be laid down. The smell of the almost hot (100° to 125° F.) pulp, the way the vinegary claret-like liquor flows out at the bottom of the (cubic yard more or less) box, the color of the seed-coats, the texture of the slippery beans, have to be learned very slowly.

After two or three, possibly four days, when the seeds have been mixed several times to mingle the cooler beans near the outside of the box with those getting too hot near the center, the batch, weighing a quarter of a ton, is taken to the drying trays or perhaps to the perforated floor of a dry-house, or possibly, if the weather is wet and the estate well outfitted, to a dehydrator.

Sometimes the seeds are washed when leaving the sweating house. If so, they present a cleaner appearance, but most growers believe that washed beans are weaker. In some estates in Venezuela the seeds are fermented in pits in the ground. Yeast germs, bacteria, and enzymes find the fermenting boxes a veritable paradise. The lees liquor is run off into a seep-tank or into a near-by stream. It might be utilized as a weak vinegar if filtered and clarified.

The tight seed-coat of the cacao bean is not so easily

handled as the loose parchment endocarp of the coffee drupelet. Moreover, the cacao seed is four to six times heavier than the coffee. If the weather happens to be cloudy, no amount of raking over, turning, stirring, on the huge trays can prevent molds from attacking the sticky surfaces of the seeds, and unless some form of artificial heat is available the batch may sour. However, if dried too fast at first the thin brownish-yellow or reddish hull may crack open exposing the purplish seed itself, which would certainly affect the price if not the flavor. A hundredweight of fresh beans gives about 47 pounds in the bag; 100 pounds of fresh pods turns out only 25 pounds of dry seed.

After some days of anxious attention, however, the beans begin to give the faint susurrant or murmuring sound which delights the tray gang. Every night and during every shower the big trays must be rolled in under a shed or a roof must be rolled over them; even dew would spoil them. In some countries the beans are "danced" when nearly dry. They are made up into a flat-topped heap, a foot deep by 6 feet in diameter, sprinkled with powdered fine red clay and then with a little water, trodden by four or five barefooted laborers, walking around and around on the heap, while two or three shovelers at the rim keep the pile from getting too shallow. After ten minutes or so every bean in the heap is glazed with a thin film of clay which protects the seed from molds between tray and chocolate factory. There is much variation in the thickness of this hull: a thin membrane over the Ceylon and Java seeds, and a tough coat on the tropical American.

Cacao goes into larger sacks than coffee, for no apparent reason: 200 pounds vs. 125 to 150. Unlike coffee it does not carry very well over long routes and great care must be exercised to avoid danger of mustiness or even dampness in the warehouses. During the World War many thousands of tons accumulated in the Accrá warehouses (Gold Coast), overflowed, grew stale and finally a vast quantity of this third-class stuff was offered gratis, it is said, to any and all

ship's captains who needed ballast on the home run; and scarcely a pound was wasted after all, they say.

Arrived finally at the factory, the beans are carefully tested, no two lots being just the same, and a blend formula worked out: so many Accrá sacks for bulk, so many Arribas from Ecuador and perhaps a little high-class Granada, which ought to make a very fair grade liquor for the candy manufacturer. Liquor, of course, is the solid ground bean, usually run, while warm and therefore semi-solid, into cakes about 15 x 25 x 2½ inches.

After a slight roast, in order to toast the skin up brittle and to bring out the delightful aroma, not nearly so strong a bake as is given to coffee, the beans are de-hulled in one machine and sent on to the nibber which breaks them into coarse and fine pieces and removes the "chit," or embryo. These nibs, or broken seeds, may be winnowed and screened out into several grades. Then the different sorts, from several countries probably, are mixed and conveyed on belts or from spouts to the hoppers of the grinders. It is a strange sight to see the warm dry rattling nibs go into the open mouth in the center of the top stone, and run out a creamy paste at the outer rim.

If the ordinary liquor, which is well ground and finished, is taken to the conching cylinder and submitted to several hours furious beating by the relentless piston, back and forth rapidly, the result is a smooth mellow cream of distinct flavor and of higher price.

The bean is marketed as cocoa powder and cocoa-butter or as some form of bitter or sweet chocolate. The shells or hulls, however, are used for stock feed. The amount of clay adherent to the hulls is seldom or never sufficient to damage their value as a cattle-feed ingredient. Cocoa shells may still be obtained, cleaned, in packages for human consumption; formerly they came in sacks, cheap and popular. The shells or seed-hulls contain about 11 per cent fat, while the "dust" (embryo chits and particles of the seed) may have around 28.5 per cent, too rich for stock feed.

VARIETIES OF CACAO

Probably 98 per cent of world's cacao is produced by the fifteen or twenty varieties of *Theobroma Cacao*. In Central America, especially in Nicaragua, and to a very slight extent on some estates elsewhere, there is cultivated a weakish but rather high-quality species, *T. pentagona*. This is sometimes mentioned as the "Alligator" cacao, a name which should be dropped, since it leads to confusion with the patashte (*Theobroma* or *Tribroma bicolor*).

The varieties of the common species may be grouped under three types, the Forasteros, the Criollos, and the Calabacillos. Of these the Forasteros turn out at least ninety pounds in every quintal marketed, while the Criollos are probably a little ahead of the "poor little squashes", to translate Calabacillos literally.

Of the variations of color of pod, color of seed, shape and size of pod, there is almost no end. According to some cacao specialists, the pinching-in of the basal portion of the fruit indicates that the type is not pure.

The commonest form of the Forastero type is a purple-red fruit with only slight ridges, the tip moderately rounded, and the base with not more than a suspicion of a bottle-neck. The seed should be slightly angled, plump, and of a pale purple or lilac shade inside. Yellows, in most tropical American plantations, are not common. They seem less resistant to disease, but there is a feeling that their beans have a better flavor, though no expert could pick out with certainty these beans from a basket of stripped seeds at the breaking heap. Some forms of Forastero pods are covered with a network of deep longitudinal corrugations and shallow crosswise warty wrinkles. Rarely the entire surface is smooth even at the base. Quite often considerable yellow color shows in the depressions between the red ridges, but practically never is a pod really two-colored.

The famous old Criollo type is much commoner in Venezuela than elsewhere. "Criollo" means native-born, and "Forastero" is the Spanish adaptation of the Portuguese

word forasteiro, meaning foreigner. The Criollo pod is much more slender and more ridgy than the Forastero and is usually yellowish. The base of the pod is more or less prolonged into a bottle-neck and the tip is rather acute, never rounded. The seed is flatter, longer, and light-colored. The flavor of the well-fermented seed is unquestionably better in some hardly explainable way, and is less bitter, but it may lack body, as the coffee blenders say. The Criollos usually are shy bearers and weak growers.

The Calabacillo has a pod about one-half the size of the Forastero, very short, with a small sharpish tip and practically no ridges at all. The color is almost always dark purplish-red. The bean is small and very bitter. The reason for planting this inferior variety here and there throughout the plantation is because the pickers can always obtain a few pods, whether rainy or dry season, pod-rots and canker or no, from these vigorous but smaller-growing trees.

The Nicaraguan *T. pentagona* is undeniably a high-grade cacao but there are cases in which canker has wiped out whole plantations. The pod is hardly medium-sized, mostly yellow, strongly five-ridged.

The patashte (*T. bicolor*) does not resemble the true cacao at all. It makes a tree 30 to 50 feet high, straight and slender. The leaves are large and rounder. The fruit is a striking object: oval or oblong, twice the weight of a Forastero, covered with a dark olive skin, with sharp-edged ridges, the larger running lengthwise. The shell is woody or almost like pottery. The seeds are large, flattened and rounded in a scanty pulp. The natives of Central America employ these seeds in making "dulces" but they are never used like true cacao.

PESTS AND DISEASES OF CACAO

There are six fungous diseases which seriously affect the price of chocolate, besides about twenty species which in certain places may sometimes attack root, stem, leaf, or

fruit. Of insect enemies cacao has perhaps fewer than any of the other major crops of the tropics.

Deer, squirrels, and monkeys spoil a few ripe pods now and then. In Trinidad and northern South America the agouti (a brown-meated rodent the size of a rabbit) and the closely related paca (the meat of which resembles chicken breast) are blamed for the loss of a small percentage of the fruits borne low on the trunk.

Pilfering by the human biped, in groves near settlements, is quite serious in many countries.

The terrible black pod-rot, *Phytophthora faberi,* is the worst pest in all cacao groves. In fact it is debatable whether tropical planters have a worse fungous enemy, since this species not only destroys at least 15 per cent of the world's cacao crop, but has long been killing coconuts by the thousand in nearly all the grove regions in both hemispheres, and lately has begun to attack the soft-barked hevea, increasing the cost of automobile tires. It works in two guises: The most noticeable is the attack on the fruits, from one-half inch in length to full maturity; and canker of the bark. Opinions differ as to which form is the more important. A minute white spore sprouting on the surface of a pod—of any size at any season, or of any variety—finds a pore in the skin. The hyphæ, or white thread-like roots, burrow rapidly into the cells and in two or three days (for a young fruit just starting) or a week or so the whole tissue of the shell is rotten, a brown spot at first, enlarging apace and finally turning black. The pulp and seeds are not attacked till after the shell has been destroyed. Mature fruits even badly affected may contain healthy seeds but they are consigned to the heap of rodent-gnawed pods and under-ripes, second-class product which may go in with a half-musty batch, 1 per cent of the total output, perhaps.

The small fruits, killed by this insidious pest, dry up, hang, black and hard for weeks perhaps, and drop off. Of course, the optimist may say that the tree could not carry

Mr. A. Dougherty.

all its set fruits through to maturity, hence the fungus might as well thin them down. It is a marvel that flowers can come out of any cushion which has had a pod killed on it. When the rot finishes the pod it creeps up the peduncle into the soft thick bark covering the button. In three days after a spore has entered, a cancerous area of brown decayed tissue—canker—is beginning to spread around the point of inoculation; and unless the tree is in good health a large area of bark may be killed, a branch or even the trunk may be girdled. Although in most groves, 70 per cent or more of the cushions have been invaded, one time or another, by their greedy enemy, a very large proportion of them block the spread of the hyphæ in some manner. Sometimes the canker, starting probably from several jab wounds made by the picker's hook, spreads rapidly and once the sap supply is cut off by a ring of infection that part of the tree above or beyond it is gone.

The brown pod-rot, *Diplodia cacaoicola,* is serious, but is not to the same extent as Phytophthora. It also may cause the terrible canker areas on the stem and larger branches.

The comparatively new water-pod disease, Monilia sp., of Ecuador is rather serious. Once the fungus gains entrance into a fruit the seeds are doomed to destruction.

The witches'-broom, *Marasmius perniciosus,* of Surinam has for twenty-five years or more caused very serious losses. Similar fungi on tea and coffee cause a peculiar bundling of abnormal branches which, of course, bear no fruit.

Various fungi invade the root system. In rich soil one can almost always find long white threads of fungus hyphæ running along the cacao roots as if looking for a chance to break in. Species of Fomes have learned how to get through the bark cuticle, and the finest trees will wilt and die as if struck by lightning.

Thread blights, Marasmius spp., are not important, except in a newly planted grove, with rotting stumps and

plenty of rain. They kill a few leaves, and hold them suspended by the threads.

Lichens do no harm to the trunk, but like mosses and ferns are unsightly. Bromeliads, or "wild pines", and all epiphytic growths should be pushed off with a forked stick once or twice a year. In very wet situations it may be necessary to brush the trunks occasionally.

The papery cacao leaf is not easily invaded by fungi, but the bark and fruits are good hunting grounds for parasites.

Plant-lice, Aphis spp., and scales often infest the flowers, peduncles, and young fruits. Boring beetles sometimes attack the branches or small trunks.

The economic status of the various kinds of thrips remains uncertain; while some of them may aid in fertilizing the flowers, others probably are harmful.

CHAPTER VI

TEA

Tea is not the most extensive beverage consumed by weight, but the most popular. Half the inhabitants of the world are more or less familiar with it. Its popularity, however, is uneven. The per capita consumption in one country, as in England, may be several pounds, while France, just across the way, uses only about 1 per cent as much. Millions of tea drinkers take the beverage as a weak infusion, never boiled, of the unfermented leaf, while others insist on steeping the black fermented article, tannin and all, and still others, millions throughout central Asia, eat it as a stew with butter and barley dough.

Tea has not as fine a flavor, to most palates, as yerba maté, not so rich an aroma as coffee, not so stimulating as kola, one of the great beverages of the future, and much less so than guaraná, not nutritious as cacao, yet it has sufficient caffein, or thein, to form a habit. For many centuries millions of individuals have avoided serious if not fatal sicknesses from polluted water by drinking it boiled with a few leaves of the Thea shrub; pure germ-free drinking water has long been scarce in Asia; 212° F., with the trace of tannic acid and a trace of copper from the kettle besides, destroys most bacilli and probably all amœbæ.

The world's second beverage is grown on about 2,000,000 acres. The crop weighs about 900,000,000 pounds. Its export value is about $200,000,000.[1]

[1] The reported total yield (presumably in trade) of both black and green teas in 1925 was only 363,507,000 pounds, of which 358,864,000 pounds was black. There was, of course, a local consumption quantum of several hundred million pounds unrecorded.

ORIGIN AND BOTANY OF TEA (PLATE V)

There has been a general belief that tea came from China. In the dripping forests on the steep slopes of the Burma and Assam mountains, *Thea sinensis* var. *viridis* reaches a height of 30 feet or more; this tree has never been found wild very far from that region. The Chinese have a tradition that a religious wanderer, Bodhidharma, brought tea from somewhere to the westward in the sixth century A. D.; but they also credit the semi-legendary and very wise Emperor Chinnung with the discovery of the virtues of the said leaf as far back as 2737 B.C.

Tea was undoubtedly growing in both China and Japan by the tenth century. It is an amazing fact, however, that Marco Polo never mentioned tea, though he traveled all over Asia from Siberia to Sumatra and from Nippon to Persia between 1275 and 1293. The Portuguese undoubtedly brought this cheering leaf around the remote tip of Africa early in the sixteenth century, but northern Europe did not begin drinking tea till the practical Hollanders imported a lot of it from the Far East a hundred years later. By about 1650 the English had taken up the habit which they have carried almost to excess. The price dropped from $2 or $3 an ounce to only three shillings an ounce at the time (1660) when Pepys sent out for his first cup of "tee".

"Té" is the Amoy dialect word for the old mandarin "cha" or "tcha", pronounced in two syllables if the tonal twist at the end is ignored. The Portuguese are the only occidentals who have adhered to the classical "cha" (pronounced, *shah*). Amoy being a prominent port for foreign ships, the low-brow pronunciation "tay" or "tee" was used by the traders; and someone started writing it "thea", the spelling Linnæus used when in 1753 he gave the plant its botanical name, *Thea sinensis*.

The Theaceæ, or Ternstrœmiaceæ, are rather uninteresting shrubs and trees, of about 175 species of which fourteen belong to Thea. It is related to the Guttiferæ. Camellia

PLATE V.—*Above:* left, tea, showing the flowers; right, Elephant grass, 11 feet high, 11 weeks old. *Below:* a thousand tons of logwood at the extract plant in Haiti.

is so close to Thea that tea has been called *Camellia Thea.*

Just how many species and hybrids of good taxonomic status are under cultivation today is an arguable question. There are said to be over 1,000 garden and trade varieties and twice that number of possible blends. Four distinct botanical varieties are generally recognized. Each of these four as well as their several hybrids and many local forms produce closely similar leaves in size, color and flavor. Formerly (till 1843) it was supposed that green and black teas were the products of distinct sorts of tea bushes.

Most of these teas endure slight frosts, especially the old Chinese Bohea varieties. The Assam indigenous types, however, require heat and humidity, both the wild trees of 40 feet, with leaves 8 by 3 inches, and the cultivated shrubs constantly pruned down to 4 feet.

CULTIVATION OF TEA

The Chinese and Japanese set their tea bushes around the steep slopes where the soil was too poor for rice and vegetables. Any group of these Theas was called by the foreigners a garden, and the English have clung to that term for the plantation. Level land is seldom planted to tea since perfect drainage is demanded by all varieties. The richer the soil is, however, the better. Tea likes humus, and an even rainfall. Altitude is of less import to tea than to almost any other crop. It does well at sea-level or 6,000 feet.

The tea leaf is substantially formed. It is normally 3 to 4 inches long on cultivated plants, rather thicker than the coffee and stiffer than cacao, maté, or khat. The under surface of the tea leaf bears a moderate number of weak one-celled hairs.

Most tea gardens are set about 5 x 5 feet, some 4 x 4, some 6 x 6, about 2,500 to 4,000 bushes to the acre. Rows look well, but on hilly land are not always in evidence.

Windbreaks are seldom necessary as there are no long

swaying branches or fruits, and nothing but a gale can injure the tender flushes on the outer branches. Tea gardens, however, have a unique feature in some places where the leaf-eating insects (small moths) are bad: flight-belts or walls of close-set trees, planted checker-board fashion, to stop the flight of the tortrix, *Homona coffearia*, from one part of the garden into another.

Since the material desired is the young leaves, the bushes are pruned, two or three times a year, in such a way that the trunk at a few inches above the ground throws out numerous ascending branches. These are kept cut back to 3 or 4 feet, so that the small-stature women and children can easily reach every twig tip. At 4 feet each way this system of pruning allows the tea clumps to occupy most of the total space, just leaving room for the pickers to walk around the bush. The prunings are left where they fall, or merely covered lightly, to furnish humus in the soil.

Chemical fertilizers of the nitrogenous class are used recently on many gardens. Pen manure when obtainable has long been popular, but may conduce to root-disease troubles if used too long or too plentifully. The prunings are insufficient as a humus-provider. There is not much room to grow leguminous cover-crops. *Tephrosia candida* is excellent in young gardens, but too bulky after the tea is grown.

New plants are raised from seed, except in Formosa, where the lower branches are layered to form new plants. The snow-white flower is followed after a few weeks by a fleshy capsule containing one or two seeds about half an inch in diameter. Tea-seed oil is a rather rare trade commodity, but in 1919 China exported 7,596,800 pounds. These large oily seeds need good care to secure a perfect stand. They should be set about an inch or more deep in rich soil, a few inches apart each way. They may be left in the seed-bed or transplanted into nursery rows. When about 10 inches high the seedlings go to the field.

The young seedling is left alone for about a year and a half, when it is topped back to induce a good number of

side branches. Expert pruners shape up the bush gradually so that no branch crowds its neighbors, and so that the whole balances well.

The economic life of a tea bush is normally fifty years or more. A famous garden in Japan produced continuously for two centuries.

HARVESTING AND GRADES OF TEA

At the third or fourth year picking can commence. By the eighth year there should be five to eight hundredweight of dry leaf to the acre—four or five times as much of the fresh leaf.

As with coffee every berry must be touched by human hands, so every tea leaf is fingered. The average woman plucks from 25 to 75 pounds of fresh leaves a day, depending largely on the grade of leaf, the size of the bushes, and other factors.

The tips of the branches, the bud itself, and a small leaf or two, make the pekoe teas. About 50,000 buds go to make a pound of dry flowery pekoe. Orange pekoe and pekoe leaf are high-grade small-leaf teas. The first and second souchongs are medium-grade teas, about 4,000 leaves to the dry pound.

Then come the coarser pluckings, leaves 1 to 2 inches long, which make up the various grades of congous. Even the stems and the dust are marketed. The dust is a cheap source of caffein (thein) for drugs and soft drinks. It is also pressed, with an adhesive, into tablets which are popular in Russia. The stems and coarser leaves go into bricks for Tibet and central Asia.

Green tea is simply the dried leaf. Black tea is oxidized, or fermented, before drying. Steam is usually employed to hasten the wilting and to prevent any so-called fermentation. As soon as the fresh leaf is steamed it goes to the rolling machine, very little hand-rolling nowadays being in evidence, which breaks down the sap-cells and thus facilitates the firing, or drying in heated pans, revolving and

stirring the charge so that every leaf is thoroughly dried but not scorched.

For some black teas the fresh leaf (75 per cent water) is allowed to wilt slowly on trays, then rolled to loosen the juices, spread out in shallow heaps to oxidize, and finally fired like the greens. Just what happens in the fermentation process is not well known, but the flavor is not much affected, and the caffein content hardly at all.

The oolong teas are semi-fermented.

In Burma and Siam fresh tea leaves are, according to Macmillan, "pressed and preserved on the principle of a silo, these being afterwards prepared for use by mixing with garlic, salt, oil and other ingredients." This is known as leppet or leptet tea. Soluble tea, or dried tea extract, should be popular, but has not succeeded well to date.

Tea seed, about 225 to the pound, contains an oil (about 10 per cent) which is in the trade.

The best leaf—as to flavor, strength, texture—is from short young branches on long old trunks and prime branches. Leaf from young sprouts on heavily pruned-back bushes is not of the best grade for two or three years after the cutting-back.

Plucking may continue from dawn till dusk, but the leaf should be sent in to the factory every few hours. If left for several hours in large baskets, as in Ceylon, or sacks, as in Java, the leaves at the center begin to ferment. The temperature may rise to 120° or even 140° F. and the chlorophyll breaks down so that a dull reddish color suffuses the mass. Red leaf material is perfectly good if promptly put into a good witherer's hands. The difficulty is that this chemically changed red leaf is commonly mixed with the fresh green leaf from the peripheral portion of the basket. This red, or fermented, leaf is, of course, only used for black teas.

The trade demands a twisted leaf, presumably because the original Chinese teas, which were all the world had up to about 1890, were hand-rolled. Really, a black tea might

be turned out with every leaf flat. The fermentation has little to do with the withering process but does depend on the amount of oxygen in the leaf mass, the condition of the leaf as to age and life, and the temperature at and the rapidity with which the various carbohydrates and alkaloids in the parenchyma are broken up by the enzymes.

PESTS AND DISEASES OF TEA

The two most serious pests are the tortrix, *Homona coffearia,* and the shot-hole borer, and they are practically ubiquitous from Darjeeling to south China. Few regions are free from the leaf-moth and nearly every garden has from 50 to 90 per cent of the bushes showing the round shot-like holes in the stem and larger branches.

Flight-belts help to check the spread of the tortrix into new gardens. Hand-picking, by sharp-eyed children, of the egg-clusters, larvæ, and pupæ reduces the infestation. Traps and sprays are not very successful. Every leaf ruined by the caterpillars weakens the vigor of the bush, and a plant struggling against the leaf-eaters cannot throw so many flushes. The tortrix has some forty other host plants, but prefers tea. It has a wilt disease which, it is hoped, may be propagated.

Against the borer, *Xyleborus fornicatus,* little can be done. Neither spray nor fumigation can reach the larvæ once they get their burrow started into the wood. The damage caused by the borer is not merely the destruction of tissue, for the bored branch breaks off easily at the point attacked. Fertilizers indirectly help to avoid very serious trouble from this pest, for the forced growth aids wound-healing and, of course, nitrogen makes flushes.

The witches'-broom disease, first noted in Ceylon in 1922, is a menace there. It is probably related to the disease of the same name which attacks cacao. It causes abnormal flushes which slowly weaken the shrub.

There are some forty-five species of fungi and bacteria which attack tea.

OUTLOOK FOR THE TEA CROP

There are two prime factors in the trend of tea as a crop: labor troubles in India, China and Japan; and the demand for land, especially in Sumatra, Java and the Malay Peninsula, for rubber and oil-palm planting. The best tea is produced in Ceylon, Assam, the Darjeeling district and the High Range in Travancore. In all the India[1] districts the output is limited and no new estates are being brought in.

The new rubber boom is hurting tea. For one-third the cost of bringing in tea a rubber planter can start a plantation on the same sort of land, though he never can avoid labor troubles.

Japan's tea export is decreasing and China's remains stationary.

Picking coarser leaves could, of course, keep up the quantity output: and many tea drinkers hardly know one cup from another.

One great boon to the tea grower is the very high price of coffee the last few years. Especially in Europe there can be no widespread use of coffee at fifty to seventy-five cents a pound; and there is no "kick" in chicory. The outlook, therefore, is fairly good for the larger estates where the laborers are still untroubled by the dread germs of social unrest.

There may be some hope of breeding up a more vigorous variety that will flush oftener and endure pests better, but little progress seems to have been made in the last decade or two. Pest control may possibly improve.

[1] India's tea acreage in 1925 was 728,800 acres; Assam had 416,500, Bengal 193,100, and South India 101,200 acres.

CHAPTER VII

SUGAR-CANE

Sugar, the greatest export crop of the tropics, has been called "the giant that walks alone." Indeed, cane-sugar is practically unaffected by the status of rubber, or coconuts, or coffee. It is a necessary food crop—the fifth in value in the world—and, aside from the three great cereals and the potato, the greatest item in mankind's dietary list of vegetable raw materials.

On the other hand, cane-sugar is not indispensable. By trebling the area in sugar-beets, the world could be sugared. Moreover, several of the palms could be impressed into service and a few others speeded up, so that several million tons could easily be added thereby. Maize is rapidly becoming a rival and there is sound reason for expecting the sunroot, or Jerusalem artichoke, soon to enter the sugar arena with good prospects of staying there. Thus is the leadership of sugar-cane gravely threatened.

Some fifteen years ago the sugar output from the temperate zone beet-root fields about equaled that from the cane plantations, some 8,000,000 tons each. Now sugar-cane has expanded around 125 per cent while the beet has merely held its position. This tremendously increased supply has somehow been readily absorbed. Today the per capita-diem consumption in the United States is over 4½ ounces, well over a hundredweight a year for each person. The saturation point is not in sight for North America, much less for Europe. China and India consume thus far only a modicum, comparatively speaking, and there is little expansion due in that direction.

It is difficult to present a true picture of the sugar-cane industry at the moment. Categorical data and principles are at best unsafe Saccharology has lately become one of the most complex branches of agriculture.

Already maltose is replacing cane-sugar in the large United States bakeries, two pounds of the former to one of the latter, it is reported. The "cereal" sugars must be reckoned with—maize glucose, dextrose sirups, even crystallized sugars.

Probably no other major tropical crop except rubber is so much in the public eye. The value of cane-sugar in the world's trade, reckoning the price at four cents a pound, is around $1,500,000,000. This is about three-fifths the total value of maize (at sixty cents a bushel), about twice the trade export value of rubber, more than double the commercial value of coffee.

Rubber and coffee require little capital aside from the land value, but cane-sugar demands a staggering amount of equipment, and this, plus the high cost of field labor and the weak demand, places the sugar-cane industry in a rather perilous predicament. A drop of a cent in the pound price would ruin many estates. Pests, diseases, long droughts, increased production of beet-sugar or maize substitute products keep the cane-growers extremely anxious. However, the public is forming a pronounced sugar habit. It must be a safe, cheap, and pleasing foodstuff, else the peoples of Europe and North America would not eat 25,000,000 tons of it, 5,000 shiploads, a year. However, some dietitians claim sugar, salt, and wheat flour are, in this order, the most dangerous foods, from the viewpoint of the physiologist and anatomist.

ORIGIN AND HISTORY OF SUGAR-CANE

Sugar-cane was first domesticated, presumably, somewhere in southeastern Asia [1] or in the East Indies. There is

[1] For some years it has been known that in Papua there are self-seeding canes under semi-cultivation by the savage tribes of the interior. This remarkable fact coupled with the reputed large

some evidence that one or more types of sugar-cane originated in the South Pacific archipelagoes, moving northward and finally meeting and blending with the other types in the Orient. The Uba canes may be a distinct species indigenous in central India or possibly some part of the Mediterranean region.

By the time (327 B.C.) that Alexander's army entered the Valley of the Indus, the crop had become a noteworthy one in India. Sugar-cane was introduced into China at the beginning of the seventh century A.D. by the Emperor Tai Tsung, who sent experts to Behar to learn the art of sugar-making. Marco Polo found the Chinese making a light-colored sugar. The crop reached Egypt about 641 A.D., Spain about 755, and Madeira in 1420.

Columbus' first attempt to introduce cane into the New World (in 1493) apparently failed. In 1506, Pedro de Atienza carried it to Hispaniola, and two or three years later the first American sugar was made there.

Cane reached Porto Rico in the first quarter of the sixteenth century. Cuba acquired the crop in 1547. Mexico was more favored, receiving a few of the precious canes in 1520. Brazil first received sugar-cane in 1532 and Peru in 1535 (or, according to Earle, in 1533).

Java began exporting sugar in 1637 and the Dutch East India Company worked out a "colono" crop system with the natives. Hawaii, however, did not make sugar till 1835, two centuries later. Before 1800 the shrewd Dutch planters began a restriction of output policy to keep up the price.

In 1590 the sweet nature of the beet was noticed but not till 1747 did Marggraff demonstrate that the beet-root and carrot actually contained cane-sugar. The trade rivalry

number of peculiar local varieties would seem to indicate that this region may have much to offer the outside world in the "noble," or thick-stalked, canes, as well as other types. It is understood that an expedition will soon be sent to New Guinea and the adjacent islands, the funds for which are available from the United States Department of Agriculture's appropriation for sugar-cane investigations.

of the beet began about 1799 in Silesia and not till 1838 in America.

Seedling cane plants were first noted in Java in 1887 and in Barbados in 1888. The great new impetus to the industry from seedling varieties began about 1920. Several hundred thousand seedlings are tested now every year.

The name "sugar" probably came indirectly through the Sanskrit word *sarkara,* meaning gravel. The people of India some 4,000 years or more ago, partly as a joke perhaps (as with the name for the coconut), named this sandy substance from its appearance; and so sugar, and its equivalent names in most European languages, was derived through the Arabic from the Persian *shakar.* The botanical name, *Saccharum officinarum,* given it by Linnæus in 1753, was founded on the Greek *sakchari.* It is etymologically interesting to note that the "h" which the Persian word carried is still audible though invisible in the folk-word sugar (which has ancient connections).

The white crystal of refined sugar is a comparatively recent invention. Before the Arabian druggists and doctors, delving into every branch of science in the progressive period between the seventh and ninth centuries, discovered how to remove the real sand from the honey-reed "gravel," the substance must have been somewhat less appetizing.

India may have imported her sugar from the Far East; the Khmers may have started the industry. The prehistoric Chinese and their forebears were familiar with several types of kaoliangs, or sorghums, and it is obvious that some of them were of the sweet-sap sort. It is possible that a Chinese traveler, knowing of the sorghum sweetness, found in his journeys southward, perhaps in Cambodia, a similar appearing reed-like plant, and on testing the wild species, discovered a still better, a crystallizable sap—cane-sugar.

The demand for this delicious but very expensive luxury grew rapidly. The Antillean colonists were at their wit's end, for the autochthons or aborigines rebelled against their treatment by the Spaniards and were exterminated. The

desperate need for field laborers was partially relieved by the activation of the decadent idea of slavery; tens of thousands of negroes were hastily brought over from the Slave Coast; and this gave cane its first great impetus. The Arawaks were slaughtered or driven to the mountains where they starved. The slaves sickened. Whips cracked. That beginning of the sugar industry in America is not a pleasant picture.

Then came rum. The cry for more sugar was drowned in the cry for rum. Another turbulent period ensued for the distracted cane-growers from Cuba to Porto Rico. By 1700 the business was in full swing, and Great Britain, alone, in that year imported no less than 20,000,000 pounds. The variety of cane was poor; there were only wooden rolls, set vertically, at first, finally iron rolls in pairs, then in sets; about a third of the juice was wasted.

CULTIVATION OF SUGAR-CANE

Sugar-cane has a distinctive system of cultivation. From India and Java to Hawaii and the American tropics there are many modifications. Details vary as to planting, fertilizing, irrigating, transporting, and the like, but the main features are everywhere as follows: large fields, the flatter and richer the better, deep plowing and careful clean tilth, except in the new fields of Cuba; holing in single or double rows or in blocks; setting one, two, or three cuttings in each hole, partly or lightly covered; hand, animal, or machine cultivation and weeding for the first few months; fertilizing before, at, or soon after planting; cutting at the ground the mature stalks from ten to twenty-two months from time of sprouting; stooling, or ratooning, of the old root clumps in position for the second, and often the third, fourth, or even tenth crop without replanting. This renewal from the root heads of the previous crop is one of the greatest factors in keeping down the cost of field operations. Where five ratoon crops can be raised (in virgin soil) with only one planting, when little or no plowing is done, and

with no irrigation or chemical fertilizers, sugar can be manufactured, by the million tons, at two to two and one-half cents a pound.

The sugar central (Plate VI).

Another positive factor in keeping down production costs is the bagasse-fuel factory practice. Wood is still used in many centrals in starting the machinery, once or twice each season. Even this means hundreds of thousands of cords. Oil fuel is burned in emergency in some mills. Water is very rarely used now for power. A few decades ago wind power was much in evidence, especially in the American Virgin Islands. Electricity is very handy about the central—made *in loco*—but too expensive for the rolls. Power utilized from the waste fiber is an incalculable benefit.

One of the very important features of the industry, which has developed largely in the last three decades, is the small farmer, or colono, system. The central is installed in the center of a cane district, usually with a fair amount of land in possession of the mill owner or the company. Then the central contracts or arranges to purchase the cane from the small grower, 10 or 10,000 tons, as much as he can grow or buy, at the rates agreed on. This system, in theory, helps both the farmer with small capital and the mill with insufficient land to keep the rolls grinding twenty-four hours a day for four to eight months.

The central, the great mill in the midst of many thousand acres of cane, has gradually eliminated the old-fashioned plantation factory. Ruins of these dot the landscape in many countries. Cane now may be brought by rail many miles to the central or sometimes by steamer.

To demonstrate the intimate connection between the field practices and the central operation, the movement should be examined. The cane arrives in ox-carts, trucks, or small or large rail-cars at one corner of the mill. The loads are dumped or lifted so that a fairly even bed of it enters the jaws of the crushers where it is broken and torn into

small pieces. Thence it passes to a set of rolls which express perhaps two-thirds of the juice. Next, traveling about six or eight inches a second, the wet bagasse or megass goes to the middle rolls which put a tremendous pressure on the pulpy mass. The nearly dry fiber may be sprayed now with hot juice or water and then put through a set of powerful rolls which exert such intense pressure that the fiber travels thence to the furnace, dry enough to burn.

The juice from the several sets of rolls is strained, pumped into heating tanks, clarified with lime and sulfur, and then sent to a series of vacuum pans, huge air-tight vertical cylinders with a small glass window for watching the crystal formation. In these the juice becomes sirup, heated by high-pressure steam coils but never scorched. Finally, the water out, the mixture of molasses and sugar crystals goes to the centrifugals. Here gravity is multiplied so greatly that after being whirled a few thousand times in as many minutes in a copper-wire basket, the liquid flies out through pin-holes in the side wall, the crystals even being douched the last few seconds to wash off the coating of black molasses so that they now go to the bagging bin clean, pale yellow, and practically dry.

As an example of the care required at the central, a few tons from Juan de la Cruz may be examined. A boy catches a measure of the first-roll juice, takes it to the laboratory, where a helper prepares the sample and passes it to the chemist. The latter places the sample in the polariscope in a small dark-room, takes a peep at it with a light beam, frowns, tries it again, then picks up the telephone: "Look out for J. C., Lot 9: away down to 10. 7." The field superintendent's office, inside of an hour, finds that Sr. de la Cruz is cutting an immature field. The cutting is stopped, labor gang moved to another field, time and money lost at that point but a thousand dollars in total output saved by the flash in the polariscope. Next comes a complaint from the filter-press boss: Lot No. 17 from Hacienda Carmen is gumming up the press dangerously. The sediment

from the clarifying tanks will not defecate properly and the press work is held up exasperatingly. The field inspector, after a frantic search of hours, locates the trouble in a patch of cane five miles away, where the gummosis diseases had played havoc in a far corner of a field. The "pan" boss telephones the central office that there is "serious trouble with Lot No. 11 from the Vega Vieja"; the grains are weak in the last vacuum pans and there are signs of too much molasses. Investigation reveals that the proprietor had not been prompt [1] enough in removing the cut canes from the field and, besides, the stem-borer was heavily infesting a part of that area.

Planting and tillage.

Most of the fields are continuously in cane, year in and year out; some Antillean fields have never missed a crop since about 1550. Fortunately a field does not have to be plowed after each crop. In rich soils the old roots will throw up two, three, or even ten crops of ratoon suckers before they weaken. Twenty, forty, even 120 tons of stalks are produced to the acre; which means two in the average bad practice to six or even fifteen tons of sugar in some of the well-irrigated heavy fertilized lava-ash lands of Hawaii.

In the pre-tractor days, three to five yokes of oxen slowly

[1] A day's delay is pardonable, but if the weather is hot and dry, cut stalks suffer the second day; millions are thus lost through enzymic changes within the tissues and through the organized ferments of micro-organisms which attack every exposed point, cuts, cracks, bruises, and cause invert sugars, acids, gums.

It is claimed that the sugar-beet industry of the United States loses some 12 per cent between field and bag: a $5,000,000 loss due to cellular respiration between digging and slicing and another $5,000,000 or more due to the accumulation of objectionable non-sugars rendered soluble by metabolic changes (enzymes?) during storage. The cane industry loses, presumably, more than $100,000,000 a year in the same way.

It has recently been proved (in Argentina) that the seedling P.O.J. 2725 has a quality which is of great value: it may be held "days or even weeks, after being cut, without suffering any loss whatever in sucrose or purity," according to W. E. Cross, in *Rev. Ind. Agr. Tucuman,* Vol. XVII (1927), pp. 213-227

pulled a heavy plow through the sticky alluvium of the broad valleys. An acre or two a day was all that was expected, and the three or four men, yelling and jabbing the sore rumps of the pitiable brutes with long nail-tipped goads, were too tired at dusk to enjoy their beans and rice and rum. Now tractors go quickly across the fields, if not too wet, eating up acre after acre.

Cane-field tillage is not mere plowing: it should be pulverization, aeration, drainage, and irrigation, so that the cane roots may have, all the time, feeding facility, air for themselves and the micro-organisms, and the proper amount of soil-moisture.

Holing is slow tedious work. There are many theories as to how far apart the hills should be spaced. The basic principle to carry in mind is to allow sufficient spacing for optimum development of the stool. Most hills are made 3 to 6 feet between the rows and 2 to 4 feet in the row.

Cane "seed" should be grown in a special plat or portion of a field where careful attention can be given constantly, to be sure that the variety is 100 per cent pure and that the plant stools are absolutely free from dangerous fungous diseases and insect pests. Fertilizer may be used liberally here. The usually two, sometimes one, three, or four, cuttings or "seeds" are either very lightly covered with earth or else the upper end is left sticking, slanting, out of the hill. These seed cuttings may lie dormant in dry weather for weeks before they produce any sprouts at the bud which each node, or joint, of the stem always carries. A new scheme has recently been put in practice; by soaking these seed cuttings in certain chemical solutions their germinating vigor is stimulated and thus considerable time is saved at the start, which may mean extra tonnage of cane at the end of the season.

Most plantations may require several varieties, some for deep moist alluvium, some for shallow-soil slopes, and some for areas where danger of mosaic or other disease may lurk. Probably no cane plantation exists today which

could not be made to yield better income by the application of this system. New seedling varieties should be under test continuously and as soon as one is found actually to surpass the old, the change should be made.

Depending on the soil, climate, variety of cane, and other factors, the young plants are hoed, weeded, hilled up, and fertilized more or less. The labor costs are heavy as compared with other major crops and the amount of fertilizer applied during the first few months is higher for an acre than for any other tropical crop except citrus fruits. In many countries heavy expense is incurred by having to pump water for irrigating the fields which otherwise would not have enough soil-moisture to supply the cane, which has a comparatively enormous evaporating surface in its foliage. If water from artesian or even deep surface wells is used, there is always danger of "salting up" the soil, gradually impregnating it with mineral salts held in very weak solution. Fertilizers are sometimes dissolved in the irrigating waters and thereby some hand labor is saved.

Machine cultivation wherever possible is advised. Tile drains, covered ditches filled with stones, or brick-bottomed drains with a vertical brick in the center, upon which the side bricks recline, permit the filling of old surface drains so that machine cultivators can be run over nearly the entire field, thus economizing on the pay-rolls. Especially just before harvest time the field must be drained as dry as possible, even to the extent of taking all the water out of the surrounding ditches by means of pumps, seepage pits, or dikes, as the lay of the land requires. Not only transportation of the stalks, but also their sucrose-content are thus affected.

Nitrogen fertilizers should force the young canes. As rapidly as possible they should be grown to the stage where they can get all their food from a vigorous well-developed root system. Potash probably stimulates sucrose storage in the culm but is of very dubious benefit to young

PLATE VI.—Sugar central in Porto Rico; cane enters on rails, sugar leaves by water at right.

cane. Lime is dangerous but, in the hands of an expert, it may be the cheapest fertilizer obtainable for a cane field.

Intercalary crops are sometimes planted with cane. Beans, cowpeas, horse beans, and others may be grown between the rows. These catch-crops are harvested at about the time the cane is ready to smother them. Only the seeds, of course, should be removed, the plants serving as a legume mulch left in position. Large centrals disapprove of this practice, but it has a practical basis, as was proved in Porto Rico during the World War.

The Earle method of ratoon cultivation [1] is recommended for old cane fields when no serious insect or fungous pests would be favored thereby. The ordinary amount of trash, leaves stripped from the stalks, is insufficient to prevent the growth of weeds between the rows, but the amount is adequate when doubled. Therefore, by putting, by fork or rake, the trash of alternate interspaces onto the intervening spaces and cultivating the cleared interspaces, a double object is gained: cultivation expense is reduced by about one-half and all the trash is conserved as a heavy effective mulch on half of the field. The succeeding season the mulched interspaces are cultivated while the tilled ones receive the trash blanket.

Since most cane diseases cannot be cured they must be prevented. Resistant varieties are a very great boon. Rotation, where a disease, such as mosaic, gummosis, sereh, or a root-rot, has progressed beyond control, is the logical practice. Pigeon pea, bonavist beans, cotton, tobacco, asparagus pea, taros and yautías or even rice, maize, or some of the many millets (if no fear is felt of graminaceous crops carrying on the infection) should be put into the danger zone and kept there till the disease is starved out of the soil. These insulation crops may not give so much cash profit an acre as healthy cane, but they return organic matter to the soil.

[1] Earle, F. S., "Facts about Sugar," June 4, 1927.

Harvesting.

Finally comes the day when the field boss, after a preliminary test of a few specimen stalks in the factory laboratory to determine whether the percentage of sucrose is up to the proper polariscope figure, gives the order to start the cutting, the "zafra" as the Spanish Americans call it. If the weather is too wet, the cutting may be delayed quite a while, although the cane is physiologically ripe. A bad rainy spell at the beginning of the zafra may cause the cane to take up so much water that its sucrose-content is lowered, even to a non-profitable percentage.

Since the machine cutters, invented some twenty years or more ago, have never succeeded in field practice, the slashing down, stalk by stalk, must be done by hand labor, and that is one strong reason for the rather high cost of sugar today. A raw recruit in the cutting gang cuts too low and dulls his cutlass, or too high and calls down the wrath of the boss; the harsh leaves sting his sweaty arms and face; the stripping of each stalk becomes a tedious task.

There are many new ways and means of cutting down costs in handling the piles of stalks from the field to the permanent rails, if the factory is big enough to maintain a rail system of feeding lines extending many miles, perhaps, into the neighboring country. Bull-carts are superseded by caterpillar tractors pulling one or two trailers, sometimes with a crane for taking up bound piles of canes from the ground and dumping them, still tied, usually, into the trailers.

Many books have been written on sugar-making and many chemists, engineers, and sugar technologists are striving to keep cane ahead of the beet and maize. In the old days the juice was boiled down, dirt and all, in open cauldron kettles and there was no expensive mill. This method is still used in back districts in the Orient and Central America; but since about 1880 the machinery end of the business has been a great expense to the cane-grower.

It is a simple matter nowadays to bag the nearly dry

yellowish crystals, but the problem is what to do with the bulky molasses, a part of which would crystallize if given plenty of time. A few big mills now are beginning to refine their own muscovado, or centrifugal sugar; until recently bone-black was used to refine it, but of late vegetable charcoal has come in.

VARIETIES OF SUGAR-CANE

From the first there have been several distinct types or sub-species in the Indian region. One of the so-called "noble" canes was the famous "Criolla," or Creole (which means native) variety which was the only one cultivated, so far as known, in the New World from 1506 to about 1800. This weak and comparatively valueless cane had somehow survived its rough treatment from India to Egypt, across northern Africa and Spain to the much better adapted lands of the New World where it flourished in the rich virgin soil of the new clearings in the West Indian jungles. For over two and one-half centuries this old variety withstood the pests and diseases and then practically disappeared.

Cristalina, known in Hawaii as Rose Bamboo, and in the British West Indies as White Transparent, is the second cane to come into prominence. For a century it held sway with few rivals in the western hemisphere; and to this day 99 out of every 100 stalks cut in Cuba are Cristalina, approximately 90,000,000,000 pounds a year. It is being surpassed, however, by Rayada or Ribbon, and the Louisiana Purple, and by the new seedling varieties, richer and resistant to the insidious diseases.

Uba, or Japanese, has recently come into cultivation. Its home was probably Burma or North India, not Japan. The writer first saw it (outside of the tropics) growing on poor gravelly hillsides in Natal in 1909. It got into Argentina about that time and is known there as Kavangire. About the time the mosaic disease began to frighten growers in Porto Rico, it was sent up from Tucuman, northwestern Argentina, and soon proved able to resist mosaic even when

planted in the midst of badly attacked canes. It is now coming to be regarded as a distinct species, *S. spontaneum.* Its rind is hard enough to break old-fashioned rolls and it is difficult to strip the leaves, but it will grow in poor soils, resist mosaic, and yield a heavy tonnage. (Plate VII.)

Mystery shrouds the origin of Otaheite, a once famous old cane which, from about the end of the eighteenth century to well past the middle of the nineteenth, rivaled the Cristalina in most plantations of the world. Captain Bligh brought some cane varieties direct from Tahiti to Jamaica in 1791. Some years previously the French brought from Mauritius a lot of varieties of unknown origins to the West Indies and Cayenne. Some of these were undoubtedly from Tahiti, some from India, and some thirteen sorts had come in 1813 from a strange source in near-by Madagascar. Otaheite, after some seventy years of popularity, succumbed to disease and left its rival a clear field.

Seedlings.

About 1887 or 1888 the discovery was made simultaneously in Java (by Soltivedel) and in Barbados (by Bovell and Harrison), that occasional cane plants produce viable seed. The accidental, or volunteer, plants were treated merely as curiosities for some years. Everyone seemed satisfied with the old sorts, but when epidemics devastated one field after another both in the East and West Indies, the cane experts made desperate attempts to find resistant varieties. During the first decade of this century it became obvious that several of the new seedlings were going to surpass the old canes, and by 1920 extensive plantings of them began, especially in the West Indies.

Many thousands of seedlings are being tested in Java, India, Hawaii, and tropical America. Of these scores will be named, each plant which passes the tests creditably being given a number prefixed by letters which indicate its country of origin. For example, P.O.J. 36, famous around the world now, was a "controlled cross" creation of the Proefstation of East (Ost) Java; B. 11569 is a lucky-

numbered product of the Barbados Department of Agriculture. At last the cane-breeders are appreciating the potential value which may lie in a hybrid between, say, a resistant and a heavy-yielding cane variety: most of the offspring may be inferior to either parent, but one plant may excel both, very fortunately indeed. From the tens of thousands of seedlings on trial in the great cane countries a few new varieties of high merit must naturally result.

Great improvement in yield and sugar-content as well as the resistance to disease has already been brought about through the planting of these new seedling varieties in place of the old sorts. A new era has begun. The limit has nearly been reached, apparently, as regards technology in the mill, agronomic systems, fertilizers, labor management, contracts for growing. But the cost of producing a pound of sugar can and will be reduced very considerably, perhaps away below three cents, by the increase in tonnage to the acre of stalks and a higher percentage of sucrose in the stalk; 50 per cent in weight of cane can be added without much doubt, and 20 per cent in weight of sugar from the ton of cane. Thus, if the average acre today gives nearly 4,000 pounds of sugar, the same area will yield around 3½ tons if and when the high-class new seedling varieties replace the old low-grade canes.

PESTS AND DISEASES OF SUGAR-CANE

The enemies of sugar-cane take very heavy toll, probably over 5 per cent. In some places they occasionally stop the work. It is a sad sight to see a field abandoned as not worth cutting, yet such things exist in all countries where lax methods permit fungous, bacterial, or insect parasites to reduce both quantity and quality of the crop.

Insects.

The cane-borer, *Diatræa saccharalis*, a pretty little pink and white moth, the caterpillar of which bores galleries in the stem, can readily reduce the pounds of crystallizable sugar an acre by 10 per cent or more.

The white grub, Lachnosterna spp., a member of the June beetle family, eats off so many roots that some fields are weakened and will not produce a profitable crop.

The mole cricket, Scapteriscus spp., can, in light soils, infest a field of young cane so badly, cutting off most of the tender shoots just below the soil surface, that replanting may be necessary, a heavy loss in pay-roll costs and six or eight weeks of valuable time.

Scale insects, frog-hoppers, aphids, root-weevils, even butterflies in some regions, weaken the plants and reduce the outturn.

Several countries are sending expert parasitologists in search for the natural enemies of the moth-borer and the beetle grub; and there is hope of success. Porto Rico [1] and Hawaii have already demonstrated the correctness of this line of action.

The moth-borer is parasitized by numerous hymenopterous and dipterous insects; some attack the eggs, some the larvæ in their galleries in the stem. Both flies and wasp-like parasites attack the grubs of the root-eating beetles. Syrphid fly maggots consume cane aphids. Fungi destroy cane scale insects. With the help from these pest-devourers the sugar-cane crop can usually be grown with a margin of profit.

Recently it was proved that a species of plant-louse, *Aphis maydis,* infesting certain grasses in cane fields and attacking the cane under certain conditions, was instrumental in transmitting the dread mosaic, or mottling, disease, which has recently spread through tropical America, Hawaii, the Philippines, Formosa, and China to Java.

Diseases.

Mosaic is one of the most talked-of cane diseases in all cane countries since about 1918. Many experts are working

[1] Box, H. E., "Porto Rican Cane-Grubs and their Natural Enemies." Journ. Dept. Agr. of Porto Rico, Vol. IX, No. 4, 1925 (issued 1927).

on it; several have, at one time or another, claimed to have found the causative organism or some germless cause. It is recognized by the peculiar checkered light and dark green patches, very small but very distinctive, in the parenchyma of the leaf-blade. Although some intelligent cane-growers still claim that they do not see any serious sugar-reducing effects of mosaic, the physiology of it is plain. If the breathing and digesting area of the green tissue of the leaf is affected by any cause whatever so that it cannot function normally, the end products—sugar in this case—are reduced proportionately. In the Philippine Islands it is reported that the reduction in sugar yield by mosaic is sometimes over 60 per cent, not that the disease actually destroyed 60 per cent of the chlorophyll in the cane leaves, but that it weakened or sickened the plants to the extent that they were delivering only 40 per cent as much sugar as a non-infested field in the same land. Roguing out the infected stools is very expensive. Planting resistant canes till the danger is past is recommended.

Sereh is a terrible disease in Java; great efforts are being made to prevent its spread. Its etiology is very obscure, but it probably belongs to the transmissible mosaic class. A similar disease has appeared in Hawaii, Malaya, and the Philippines. It causes the suckers to fan at the stool base. Like most cane diseases it is to be avoided, since no cure has yet been found.

Root-rot fungi are so bad in some regions that they practically destroy whole fields. There are several distinct species. The attacked plants starve as the roots are killed as fast as they can grow. Diseases of this class are dreaded by the mycologists. They stealthily work underground and they may appear anywhere at any time, especially in badly drained soils. Research indicates of late that several fungi work together, saprophytes, parasites, and facultatives.

Gum disease is one of the most difficult enemies the cane-grower has to combat. It is caused by *Bacterium vascularum* and other species. One of the worst effects is the

2,500,000 tons. Little extension is possible without disturbing food-crop areas for some 35,000,000 inhabitants.

Brazil with nearly a million tons stands fourth. Much available cane land awaits development there.

Hawaii turns out around 750,000 tons. Little land is left suitable for cane culture except by heavy developmental expenditures, for irrigation particularly.

Porto Rico and the Philippines each turn out from half to two-thirds of a million tons. The latter country has plenty of room for expansion, but the former has nearly reached the limit unless economic conditions are upset.

The United States mainland (Louisiana mostly, Texas, and recently Florida) produces from less than 100,000 to over 200,000 tons of cane and about 800,000 tons of beet. Both cane- and beet-sugars can increase very considerably in the near future if the price holds.

Santo Domingo can easily expand her crop of some 350,000 tons; but Haiti has only a small area adapted to this crop.

The Tucuman district of Argentina is forging ahead toward a half million tons.

The British and French West Indies together can turn out over a quarter million. Mexico can produce 200,000 tons, with plenty of expansion room. Central America hardly exceeds 135,000 tons. British Guiana turns out over 100,000 tons and can expand. Peru is opening up a new district and will probably soon be exporting 400,000 tons. Colombia, Ecuador, and Venezuela combined produce mostly the brown massecuite caked sugar for local consumption.

Formosa turns out over half a million tons and can expand a little more. China is believed to produce about 350,000 tons.

Australia now produces from about 400,000 to nearly 600,000 tons.

Natal produces around 215,000 tons.

Mauritius produces nearly a quarter million tons and Reunion about one-fourth as much.

Egypt makes around 100,000 tons for local consumption; Fiji the same amount.

Mozambique at present produces less than 100,000 tons but her potential sugar area is immense, five great river valleys with thirty-foot-deep alluvial soil.

The Congo Valley could supply the world.

From the above data it is obvious that there is no danger of a land shortage; without the two great tropical water basins, the Congo and Amazon valleys, there is a possible expansion of 20 per cent in area. This would hardly accommodate the steady 5 per cent increase in sugar consumption, setting aside the sudden 75 per cent increase in cane-sugar production due partly to the World War. It must be remembered that the new seedling varieties and the improved field practices will very greatly assist in the expansion of the outturn; these two factors will permit of a 40 per cent increase in sugar yield without field area extension.

By the 1931-2 season the civilized world will require about 30,000,000 long tons of sugar; and by 1935 the present production will need to expand to the extent of about 12,000,000 tons. The sugar-beet can and must do its share in this increased output; both Europe and North America can easily add 50 per cent to their production. Brazil, Cuba, Mexico, and Mozambique can take care of the cane expansion. Europe produces around 8,000,000 tons, all beet except a few thousand tons of cane in southern Spain; North America, Mexico, Central America, and the West Indies, about 9,000,000 tons (less than a million of beet); South America, 2,000,000; Africa, 750,000; and the Far East, around 8,000,000. Therefore, the western hemisphere turns out nearly 11,000,000, and the eastern over 17,000,000 short tons.

Other sugars.

How much the cereal sugars will affect the price of cane-sugar in the next decade will depend on the technique of the manufacture of the former and to some extent on

the public attitude toward these rivals of, or substitutes for, cane- and beet-sugar. Maize sugar is wholesome, cheap, and it can be very abundant. Dahlia sugar is a possible competitor, but as a crop the types of dahlias now in evidence fall far short of the ideal. Unquestionably they can be bred up to a great extent, but they lack stamina now.

On the other hand, the sunroot, *Helianthus tuberosus*, has a chance as a rival of cane. The many horticultural varieties now under test in various countries have some faults but many good points. There are some sixty species of the genus scattered from Canada to Argentina; most of them are North American. The tubers of three species, at least, were used by the aborigines, but it appears they were seldom planted in fields. The pre-Inca race had yacon (Polymnia) varieties, closely related to the sunroot, in their terrace fields. The sunroot, or topinambour as it is called in Egypt, grows 6 to 12 feet high and looks like a much-branched sunflower. The white, yellow, pink, red, or purple tubers are 4 to 8 inches long by 1 to 3 in diameter. About 4,000 hills go to the acre and the yield runs from a few to 20 pounds a hill; 2,000 to 60,000 pounds is the acre yield range. The tuber contains about 18 per cent of inulin and sugars. A process has been worked out, largely by the United States Bureau of Standards, whereby this inulin is transformed into calcium levulate, and thence into levulose. Levulose is about 70 per cent sweeter than sucrose—a very important point. These tubers are excellent stock feed and are also used on the table. The leaves and small branches are an excellent forage, especially as silage. Seedling varieties are being raised by the United States Department of Agriculture.

No picture of the sugar industry is complete without ka-á he-é, *Stevia Rebaudiana*. This composite herb indigenous in Paraguay has immense possibilities as a dietetic commodity, not to say food. The leaves contain a glucosid, in combination with soda and an aromatic resin, which has a sweetening power from 150 to 200 times greater than cane-

PLATE VII.—The famous Uba sugar-cane in flower, on the site where Dr. J. R. Bovell (in foreground) discovered the seedling canes, in Barbados.

sugar and is soluble in water. This aromatic resin and the glucosid can be extracted from the leaves and used in the liquid form for preserves; it does not ferment and is non-toxic. This saccharine-like substance is supposed to be an ideal and safe sugar for diabetics. Ka-á he-é should be grown on a large scale. Cutting could be made once or twice a year and the commercial extract or perhaps powder (from the dried leaves) should be a very valuable adjunct to the canning industry as well as to the medical profession.

Another factor which must be considered is the possibility of synthetic sugar. If, as it is said, it is possible to force a combination of the three parts, water, carbon dioxide, nascent hydrogen, together with catalyzers and intense pressure, heat, or chemical strain in an autoclave, some of the 200 or so kinds of sugars may be made synthetically. Quite a number of disaccharoses have already been manufactured this way.

Utilization of by-products.

The utilization of cane molasses is a very interesting and important branch of saccharology. Alcohol is the logical safety-valve of molasses (or sugar) surplus. Several of the sugar-producing countries now have industrial alcohol distilleries [1] running successfully. Recently efforts are being made to manufacture proteid feedstuffs from solutions of molasses to which certain mineral salts and yeast are added; the micro-organisms combine atmospheric nitrogen with the carbohydrates of the solution, forming a scum which can be removed, dried, and used as protein-supplying ingredients in feeds or even in foods. This plan may help to keep up the price of sugar.

[1] Germany has over 53,000 distilleries; United States, about 100. An acre of sunroot should yield 840 gallons of alcohol; the sugar-beet acre, 430 gallons; mangolds, 228 gallons; and potatoes, only 184 gallons.

Methanol, or wood alcohol, is now imported from Germany to United States in large quantities—in competition with the grain and molasses spirit. The latter spirit can now also be manufactured from sawdust.

Utilization of the bagasse in the manufacture of papers, cartons, and building materials has already proved profitable on a comparatively small scale. A large part of this material could go into cellulose work, especially at those centrals located on the seacoast, where petroleum could well be substituted for the bagasse as fuel. If sawdust can be transformed into sugar, cellulose might be utilized in the same way.

Unfortunately little has been done toward utilizing the cane leaves. Instead of drying them for hay or, better, a hay meal, they are left on the ground—hundreds of thousands of tons—and in most regions they are burned as soon as dry enough, thus losing the humus material needed for the soil surface. The feed value of cane leaves about equals maize stover. The waste should be stopped.

CHAPTER VIII

THE CITRUS FRUITS

THIS great group of food fruits is one of the three oldest in cultivation. It is only in the last half century, however, that citrus fruits have acquired much commercial prominence. Several kinds have been cultivated for about 3,000 years. Two species, the orange and grapefruit, now bring an annual gross return, to a rather small number of growers, of over $300,000,000 from about 95,000,000 boxes of fruit.

Although most species of the citrus group will endure slight frost, all are primarily tropical; however, most of the commercial groves lie outside of the tropics. As competing rivals, the orchard fruits are in first place, bananas second, with grapes and pineapples not to be disregarded.

After years of propaganda it appears that the European market is opening up; this stimulates considerably the production end of the enterprise in America. One or two areas are extending perhaps too rapidly. Frost limits the expansion northward.

Canned grapefruit has been marketed by the million cans for five years, yet a large percentage of the American public, even in the eastern states, never has heard of the article. There is obviously a great field for the Florida and West Indian canners in the next twenty-five years. The production areas may extend into Mexico, Central America, and even Brazil. Since the canned grapefruit is really better than the fresh article, and since cannery units can now be carried easily to the districts where the growers want them, there is every reason to believe that a very interesting and profitable industry is beginning.

One factor which contributes largely to the strong demand for both oranges and grapefruit is the prevalent belief that these fruits, with their citric acid and vitamins, are good alteratives and stomachics—"appetizers". Some growers claim that they should not attempt to produce the superior sorts of grapefruit because the public prefers the bitter sourest kinds. New varieties, partly from the Orient, India and Malaya largely, and partly from hybridization and mutations, will come forward, but they will not affect the industry much for several years.

Citrus growers have their troubles, but they usually obtain comparatively high prices the greater part of the year. Outside of the tropics the orange or grapefruit producer must submit to the exigencies of the seasons, while the intelligent orchardist within the torrid zone can control the time of flowering, and consequently of fruiting, of his trees, thus sending his fruit onto an open market in the off season.

California and Florida, rivals for leadership, together far surpass any other district. The countries on the north and east sides of the Mediterranean rank second. South Africa comes in third, struggling for the growing European trade. Porto Rico with a crop of less than 3,000,000 boxes probably sets the record for high yields in grapefruit. Isle of Pines, Cuba, Jamaica, and Trinidad are taking their places. Brazil is beginning.

Reckoning the value of the groves, buildings, canneries, and the like at five times the yearly income, this may be considered as a sesqui-billion dollar industry. The per capita yearly consumption in the United States is: oranges, 58 fruits; pomelos or grapefruit, 5 fruits; lemons, 16 fruits.

The citrus fruit juice branch of the industry has a fair outlook. If it is true that 8,000,000,000 bottles of soft drinks are consumed annually now in United States, the value must be near a billion dollars. While most of these drinks are synthetic at the present moment, the public sentiment is favoring pure fruit juices and flavors. If, as seems

probable, the producers of oranges, pomelos, limes, and lemons can capture a fair share of this great business it will give an added impetus to citriculture, especially in California, Florida, Texas, and the West Indian countries. The natural or concentrated juice can be shipped long distances in refrigeration and held for six months with little or no deterioration in flavor. Various by-products, ranging from citric acid (mostly from cull lemons) to candied peels and cattle feeds are already on the market.

ORIGIN AND BOTANY OF THE CITRUS FRUITS

So far as known all the important citrus fruits were first domesticated in southern and eastern Asia. From southeastern China to India, down through the botanically rich countries of Siam, Indo-China, the Philippines, and especially perhaps in the East Indies, they have been discovered in the wild, tasted, and finally very gradually given a place of honor in the village clearing. Citrus fruits were not at the first domesticated just for their eating qualities, but for other reasons. Citron was one of the commonest plants in the Hanging Gardens of Babylon, but Semiramis could not have bought a pound of properly preserved citron peel; it was grown for citron-oil pomade and probably citron-flower toilet-water.

The genus Citrus contains about fourteen species, practically all of which are native to southeastern and southern Asia and the neighboring archipelagoes. Africa and Australia have many close relatives, some of which are forest trees 60 feet or more in height. The family, Rutaceæ, is a comparatively small distinctive group of about 1,000 species well scattered over the world; it is related to the Meliaceæ, or Mahogany family. All citri are shrubs or small trees, ranging from 3 to 30 feet high.

One of the outstanding factors in connection with the horticultural side of citrology is the ease with which hybrids may be made between almost any two related species. Scores of these crosses are in evidence in American planta-

tions and experiment stations. Moreover, in the Orient there are numerous natural hybrids. In the Philippine Islands certain species and subspecies were found, between 1910 and 1916, only in exceedingly limited areas,—in some cases only a dozen or so trees of a kind could be discovered. Yet these were under semi-cultivation and had specific names.

Southern Asia has numerous types of Citrus that have not yet been studied well, much less carried outside for commercial tests. Here lies a great field for horticulturists.

Another remarkable feature of these plants is their common tendency to sport under cultivation; not only striking sports, distinct new varieties worthy of propagation, but also little variations in the buds and branches on the same tree. The sweet orange, as an example, may be a natural hybrid. Some varieties come true to seed, others vary widely even in the case of seeds from the same fruit. This so-called species may be a cultigen; the wild trees, if any ever existed, long ago disappeared.

The citrus group is perhaps the most important class of commercial dessert or luxury fruits. These plants do not have as great potential value, as food crops, as does the banana group, but they are far easier to work with and more interesting horticulturally.

FIELD PRACTICES

Disregarding the haphazard methods of small farmers in both the Orient and Occident, the crop system of modern citriculture compares favorably with the best practices among producers of the deciduous fruits. The enormous returns from groves maintained on modern scientific lines has called forth every fine point in buddage, fertilizing, and field management. The last two decades have witnessed a great advance, especially in the United States.

Best yields are obtained in the commercial varieties of oranges and grapefruit at sea-level. In India some varieties do well up to 4,000 feet. Some orange orchards thrive in

tropical America at 2,000 and even 3,000 feet, provided winds and rains are not too strong.

The grove site should be chosen with a view to economy of transport. Citrus fruit bulks large and though it can come down steep and slippery mountain trails, two boxes to a mule where mules or hinnies are cheap, as in western Porto Rico or central Jamaica, the grove does better in a valley or coastal plain where ox-carts and light trucks can be used.

There is, or has been, a belief that the citrus fruits need a rest period, or short wintering, to retain their vigor. In the Orient, for example, orchards may be dried off (if irrigated) and the earth drawn away from the bases of the main roots, thus causing the trees to shed part of their leaves and rest. Nothing is gained in the end by resting either an orange or a pomelo at any time or at any elevation below 1,500 feet. Gentle continuous pushing, with small doses of fertilizers several times a year, spraying as often as required, pruning without shocking the tree, is necessary for success in citriculture.

Outside the Orient, probably 95 per cent of the commercial trees are one species or race below ground and another above. There are widely variant opinions regarding the proper stock for each of the common grove varieties. In United States and West Indian practice these points are generally agreed on: the rough lemon is best for shallow, poor soils; the sour orange for deep soils; and the grapefruit (seedling) for general use.

Strong winds do harm, especially to young trees when flushing. Windbelts are gaining favor almost everywhere, though it must be admitted that the average grower is prone to set a belt of poisonous bamboo instead of some better species. For the tropics the two best medium-sized trees for citrus windbreaks are the madre de cacao, *Gliricidia sepium*, and the malay-apple, *Eugenia malaccensis*.

Fortunately the roots of most citrus plants are excellent feeders; they quickly take up fertilizer, resist nematodes,

and hold the top firmly. They are less particular about soil types than most crop plants. In the old orange district north of Guadalajara, in the west-central mesa of Mexico, the 100-year-old trees flourish in pure red clay, while in southern Florida similar trees do just as well in white coral sand. Hardpan in tropical America is a serious negative factor; citrus species having a strong taproot suffer severely where the pan is within 20 inches of the surface. Cutting the taproot at the time of setting out the tree is recommended; a small charge of dynamite cracks the soil and, if the pan stratum is not too thick, provides better drainage. Sour soil pockets and areas where the water-table may remain too high for several months in the year must be avoided. Root diseases may occur anywhere at any time, but under expert management the loss of trees in well-drained soil of 2 feet depth is negligible.

The modern producer of oranges and pomelos is learning crop control by means of fertilizers. To hasten the maturity of a certain crop of fruits he broadcasts a heavy application of phosphoric acid stuffs; to retard the maturing of a crop he cautiously puts on either sulfate of ammonia or (if in a hurry) nitrate of soda; then to harden up the pulp, thin down the rind, and improve the rag-content, he spreads on a liberal dose of potash. Many grove superintendents demand that their bearing trees have a dollar's worth of fertilizer a year; this is only fair when the trees are giving him fifteen to twenty-five or more boxes each crop. There is no fast rule for the number of times the fertilizer is applied; the wise grower studies the symptoms of the leaves, flower-buds, fruits small and large, and the weather. One to 3 pounds in several doses may be given to trees the second and the third years. This fertilizer may contain 5 or 6 per cent nitrogen, the same quota of phosphoric acid, and 3 or 4 per cent of potash. Bearing trees, say eight to fifteen years old, should have from 10 to 50 or even 75 pounds a year of a mixture containing less nitrogen and more phosphoric acid. A 4–8–4 or 3–10–5 fertilizer is

recommended for ordinary conditions. The two to four applications should be made in the less rainy seasons.

Irrigation is a basic factor in the old areas of California wherein the long summer drought would tax the vitality of the trees to the limit. The irrigation, as well as the fertilization of young trees, is usually overdone.

Cover-crops are almost a necessity in young groves. At least a large circle around the tree should be blanketed by some close-growing legume or by some form of trash or straw mulch. For small trees the varieties of cowpea are almost always the easiest to handle. Vetches or field peas may do better in the winter season north of the tropics. Crotalaria and beggarweed are old favorites for growing in the interspaces where there is plenty of soil-moisture. A recent East Indian legume, *Tephrosia candida,* is likely to become very popular, especially in tropical America; it grows to 7 feet and may be headed back several times, the tops forming a cool mulch over the nitrogen-gathering roots. At no stage can citrus fruits endure grass near their roots.

The nursery is frequently a neglected part of the citrus plantation. The seeds should be hand-picked to avoid weak seedlings. The seed-bed may be partially shaded. The young plants must be watched continually to see that no weeds check their growth and that no scales, damping-off, nor leaf-scab appear. When 10 or 18 inches high, the seedlings may be set out into the budding rows. For the convenience of the budder these rows should be double with a reasonable space between. The plants may be set 12 to 18 inches apart in the row; the two rows may be 18 inches apart and the budder's path 3 or 4 feet wide. When taking up the seedlings from the seed-bed their taproots should be cut back to 6 or 8 inches; the tops, if leggy, may also be cut back to about 12 inches. The optimum size of the nursery plant for taking the bud is about ½ inch in diameter at the soil surface.

Rough lemon seedlings usually need repeated applica-

tions of bordeaux mixture to control the scab fungus. Sour orange also may require it.

The usual budding methods for deciduous fruits apply to citrus seedlings. Most growers are too careless in selecting their cions, in accurate tagging of the buds before and after setting in the stocks, and in care in handling, wrapping, and unwrapping the buds. Budwood, carefully packed in sphagnum moss and kept cool, will remain viable for three or four months if necessary.

Much has been written regarding bud-variations of the citrus group; the question has many angles. A. D. Shamel has obtained startling results which appear to demonstrate the principle that there is an innate tendency in every bud, branch and tree to break away from the fixed type, to sport. Hume [1] succinctly states the case from the conservative point of view: "Fruits of the citrus group are very much mixed and of complex origin. . . . Perhaps the more artificial the conditions under which citrus fruits are grown, the more prone their buds are to vary. . . . All variations must not be attributed to bud-sports. Many variations in size and shape of fruit, thickness of peel, color, seediness, vigor, and yield, noticeable in whole trees, parts of trees, or single branches, may be brought about by differences in stocks, moisture, soil, food-supply, and many other imperfectly understood environmental factors. These cannot be perpetuated by selective propagation and are to be differentiated from variations due to sporting."

Budding may be done in the tropics whenever the stock plants are making flushes, three to six times a year. After the buds take, the tops of the stocks should be lopped in order to force more sap into the growing bud. The tops, lopped inward in each of the pair of rows to give access to the buds, may be entirely removed as soon as the new bud-shoot has made a few inches growth. The budder should put in 500 to 800 buds a day, tied, or with a helper to tie about double that number; about 85 to 95 per cent of the

[1] Hume, H. Harold, "The Cultivation of Citrus Fruits," 1926.

buds ought to grow. The soft flush of the new bud needs some support usually; a three-foot stake stuck into the earth close to the stock serves for tying up the weak shoot.

Old trees may be top-worked, *i.e.*, the branches or even the trunk may be grafted (crown or cleft) with cions 2 to 4 inches long. Small slender twigs of a rare new variety may be inserted into branches of an old tree, thus hastening the appearance of the new fruit.

The pruning shears should be kept out of the grove for the first year: every leaf counts. In the second and third years the tree may be gently and gradually shaped up. Afterward only cross-branches, water-sprouts, and weak limbs need be removed.

The nursery tree is usually mishandled; it should be cut back, top and bottom, when taken up for planting. It is also generally shocked badly in setting into the grove. The roots should never be exposed to wind or sun, and the earth should be carefully worked in around the roots, firmly and with no air-pockets.

There are numerous grove planting systems. The grower must consider the strength of his soil and the kind of stock and then decide how much crowding he can safely do. The large species of citrus are usually set out at anywhere from 15 by 15 to 35 by 35 feet; 25 by 25 feet, or in high or dry soils a little less, is probably the optimum for orange and pomelo orchards and this distance gives 70 trees to the acre, rectangular planting, or 126 quincunx.

If well set and if no set-backs occur, there should be a few fruits the second year after planting out, say three and one-half to four years from the time the seed entered the seed-bed. The fourth year ought to see a paying crop. From ten to twenty years orange, grapefruit and pummelo trees are in their prime. The mandarin, lemons, citrons, limes, are not so long-lived.

Yields range from 5 to 30 boxes a tree for the large species. The average yield for a well-managed pomelo or orange orchard should be around 1,000 boxes an acre, say 15 a tree,

for trees in their prime. Of course, many groups of trees, blocks of several acres perhaps, may double that figure. The record is probably over 50 boxes, making it possible to get over $10,000 an acre (when the gross returns are $4.00 a box); no other fruit species can surpass this.

The pomelo grower has one advantage over the orange grower. Canned grapefruit has been for five years a new food product in rather strong demand, and much of the fruit for the twenty canning factories in Porto Rico and Florida is the fine-flavored russets—those fruits having more or less of russet-colored blemish on the rind. These and the under- and over-size fruits go direct from grove to cannery. While these cull fruits bring only $20 to $40 a ton usually, it is a great relief to the packing-house manager because he now sorts close on the fresh fruit grades.

PESTS AND DISEASES OF CITRUS FRUITS IN THE TROPICS

Over 100 kinds of parasites besides insects attack citrus trees. Fungi are the most numerous, bacteria are serious, and nematodes are probably more injurious than commonly believed. There are about forty species of insect pests. This array of citrus enemies can only be handled properly in special works on the subject.

Diseases.

Mal-di-goma or foot-rot is exceedingly destructive. It attacks the base of the trunk, causing gum to ooze out of the bark. It may quickly girdle the crown and extend down the main roots. The infected bark and wood must be removed and the wound painted with a fungicide solution. It is prevalent in all citrus districts of the world. A species of Phytophthora is supposed to be the causative agent. Sour orange or rough lemon stocks are resistant.

Damping-off is the result of several fungi attacking young seedlings, in some cases destroying practically every plant in the seed-bed. Bordeaux mixture usually checks the spread of this trouble. The seedlings should not be

given more than enough water to prevent wilting in the dry season and the beds should not be started in the heavy rains. This discouraging trouble is everywhere common.

Both in the Orient and Occident there are several peculiar gum diseases of the bark and sap-wood of the trunk and branches; in some cases even the fruits may be attacked. The infected bark and wood should be removed and the exposed area painted.

Anthracnose or wither-tip, *Colletotrichum glæosporioides*, is everywhere prevalent on all citrus fruits. It causes serious damage to trees which happen to be below normal in vigor; leaves, flowers, young fruits and the tips of branches are attacked. This fungus is highly variable. A closely related species is threatening the lime industry of the West Indies. Fungicide sprays and careful pruning of the infected parts are usually successful. A good application of nitrogen may enable the tree to throw off the parasite.

Scab is an extremely common and injurious disease caused by *Sphaceloma fawcettii.* Nearly all citrus are attacked, fruit and leaves, but the rough lemon and sour orange are most susceptible. The damage to the pomelo industry runs into hundreds of thousands of dollars annually. Bordeaux mixture if carefully used keeps it in check, but repeated applications may, of course, cause severe dropping of young fruit. Fortunately this parasite can injure only the very young leaves and fruit.

An oriental bacterium, *Pseudomonas citri,* was introduced in the Gulf states on foreign citrus about 1910 and before its virulence was recognized several foci were in evidence. On account of its extreme infectiousness the only way to combat canker was to burn the whole tree even if only one leaf showed the suspicious small brownish spots. Several million dollars were spent before the disease came under control, only a few areas in Louisiana and Texas being still in doubt. In the Philippines and Japan canker is much less virulent, otherwise their citrus fruits might

long ago have become extinct. India appears free thus far, but Ceylon and the East Indies are afflicted.

China and the Philippines have a devastating bark-rot disease of unknown etiology. Many fine mandarin groves have been wiped out by it; the bark blisters, and the trunk may be girdled in a few weeks. The remedies are precarious.

Pink disease is one of the commonest fungi throughout the tropics. It attacks the trunk and branches of practically every tropical plant having a woody stem. It is difficult to control, and it is really remarkable that it has not ruined citriculture in the more humid regions. *Corticium salmonicolor* is the causative agent.

Frenching or mottled leaf is a peculiar disease, probably largely physiological, common in most of the world's citrus districts. "Feeding up" seems to be the only remedy.

Die-back is a fairly common gum disease of citrus, probably physiological, at least to a large extent, but several fungi seem to be connected with various forms of the trouble.

Three or four serious root-rots, black, white, and brown, attack citrus as well as rubber and even root-crops throughout the tropics. No real remedy is known. Citrus fruits are also attacked after picking by several molds and mildews which cause at times severe losses between the grove and the consumer. A borax bath reduces the loss from blue-mold in the shipping boxes; but the use of chemicals in the washing tanks of the packing-houses is not so popular and effective as might be expected.

Insects.

In tropical America the worst insect enemy of citrus is the parasol, or leaf-cutting, ant, Atta spp. Cuba, Mexico, and Brazil are badly infested. There is hope that a form of some of the new cyanide compounds may give the grower protection from this terrible enemy, which, C. H. T. Townsend estimates, causes agricultural damages to the extent of $100,000,000 annually—the world's worst insect pest.

The brown ant, *Solenopsis geminata*; is a rather serious pest in young orchards in tropical and sub-tropical America. It girdles the branches and trunks, apparently in the effort to obtain a good supply of the sweetish gum which follows their attacks. Contact poisons, poisoned bait, and traps are successful if persistently used.

Throughout the tropics, particularly in the Orient and South Africa, multifarious species of locusts, bugs, and butterflies attack the leaves and fruits. In Mozambique a stiff-tongued butterfly punctures the rind of oranges and leaves invisible pin-holes which, after a few days, become foci for bacteria.

The worst pests in Mediterranean and United States citrus orchards are scale insects, whiteflies, and aphids. The prodigious reproductive powers of these pests render them very dangerous enemies even in old well-managed groves. Contact sprays, dusts, and fumigation are effectual, but only in experienced hands. The purple and red scales are probably found in every citrus grove in the world. The six or eight whiteflies of California and Florida, the black-fly of Cuba and Jamaica, the Florida aphid may be more difficult to control at times than the scales.

The Mediterranean fruit-fly has caused much discussion, at least in literature, during the last decade. It has spread to Australia and Hawaii, but in the latter country it is reported that parasites are now killing about 50 per cent of the maggots in the fruits. There are many tropical fruit-flies, but they seldom attack any but very ripe oranges.

Thrips and mites (Phyllocoptes) are very troublesome in some seasons in dry weather. Since their life cycle from egg to adult may be only ten to fifteen days, they appear and disappear in groves with amazing suddenness. They are readily killed if a dust or contact spray can be made to reach them.

Birds occasionally pick holes through the rind of ripe oranges in the dry season; in some groves in Porto Rico their mischief may cause half the fruit to drop.

Entomogenous fungi render valuable service to the growers. In humid localities the soft-shell scales are kept well in control without sprays. Frequently three species of these carnivorous fungi may be seen preying on the scale colonies on a single tree. Bordeaux mixture, of course, kills these beneficial parasites; hence an increase in scale infestation is expected following such sprays. Artificial propagation and mechanical distribution of these fungi will be worked up into an important branch of citrology in the future. Several beetles, some Syrphus flies and many Hymenoptera also help to keep in check the citrus scales and aphids; these, also, could be distributed from official insectaries to needy groves.

SPECIES AND VARIETIES OF CITRUS

The orange.

Of the four major and six minor species of Citrus which produce the $300,000,000 worth (export value) of fruit, there is only one of very high commercial importance, the sweet orange, *C. sinensis.*

Northern India or Assam was probably the habitat of the wild trees of this species. Just when it came under cultivation will never be known, probably somewhere around 1500 or 1000 B.C. From some port on the south side of Asia the Portuguese spice traders carried it to Europe at the beginning of the sixteenth century, 400 years after the Arabs had taken the sour orange (probably by the land route) to Sicily. The Spaniards began cultivating this improvement over the Arabs' orange about the middle of the sixteenth century; and they distributed it to their new Antillean colonies and to Florida at that time.

Today the orange crop is worth over $200,000,000. It is of interest to note how and where it is distributed:

United States	34,000,000	boxes
Spain	23,000,000	"
Italy	8,000,000	"
Other countries (est.) ..	5,000,000	"

The Levant and Porto Rico each ship around 1,500,000 boxes. South Africa, Japan, Brazil, Australia and the Algeria-Tunis district combined probably produce about 2,000,000. Local consumption in India, Malaya and China is not so large as might be expected but a million or two boxes are probably consumed there. United States, South Africa and Brazil seem to be increasing their output rather rapidly. From around 14,000,000 boxes in 1905-6, the United States crop has jumped in twenty years to about 34,000,000. Still the retail prices hold good, and, stranger still, the United States imports oranges.

There are several more or less distinct types of this species, as follows: The Navels, of which there are eight or ten commercial and numerous local varieties; the Bloods, with five or six Mediterranean varieties, introduced into United States; the Mediterraneans, comprising twenty commercial and many local forms—the most important group of closely related food fruits in the world; the Spanish type also includes twenty grove varieties; the wild seedlings, of which there are scores of localized varieties in tropical America, Asia, and the oriental island groups. Porto Rico, for example, can pick nearly half a million boxes of these wild fruits in the coffee plantations. Some forms are among the very best oranges of the world, considering flavor and color. Since the trees are never sprayed nor pruned, the fruits have a neglected look. For centuries these trees have held true to type and always on their own roots. Sports sometimes do occur, however.

The Bahia Navel vies with the Valencia as the most popular orange. The Pineapple and the Parson Brown are probably next for bulk shipments.

The popularity of orange juice as a beverage has greatly increased since 1920. Besides the enormous consumption of the fresh juice, there has arisen (in California) the industry of bottling and canning the juice, generally concentrated. The per capita consumption of soft drinks is now around seventy bottles a year, and a growing portion

of this vast amount is supplied from oranges. Formerly about 100,000 tons of cull oranges and lemons were wasted in California and Florida every season.

Orange peel is a new commercial product.

Oranges have been canned. The difficulty of removing all the rag membranes, however, is too great unless a strong demand eventuates.

Pectin is now manufactured from cull oranges. The pithy part of the rind is used; the horticultural engineers had to impress into service an astronomical word, albedo, to apply thereto.

The pomelo or grapefruit.

Probably no cultivated fruit of commercial importance ($30,000,000 or more a crop) is so shrouded in mystery and ignorance as to its origin. Recently it has been separated from the pummelo or shaddock, the latter remaining as *C. maxima* or *C. grandis*, and the former taking the name of *C. paradisi* or *C. maxima* var. *uvacarpa* if one does not wish to separate it as a distinct species.

The pomelo is probably a West Indian sport from the old shaddock, which was one of the oriental pummelos brought into the West Indies by Capt. Shaddock, probably in the seventeenth century. Among the very numerous forms and subspecies of pummelos found from Japan and southern China to India and back across the Pacific, none seems to resemble closely the Antillean fruit. Therefore, the latter may be regarded as a true and quite distinct sport till some further light is thrown on the matter. It is possible that the pomelo was brought to Florida about 1809 by a Spanish nobleman, Don Philippe. It received little attention except as a lawn decoration till about 1890. Since 1905 production has increased rapidly, especially in Florida. Some acreage data for 1927 follow: Florida has about 60,000 in bearing and around 20,000 non-bearing. Texas reports some 11,000 bearing and perhaps 50,000 or more in the formative stage (some of which may be thrown

PLATE VIII.—*Above:* Seedless Siamese pummelo (*Citrus Maxima*). *Below:* the kalpi (*C. Webberi*), a Philippine fruit possessing the good points of both mandarin and lemon.

out). California has 5,417 in and nearly as much more coming into bearing. Porto Rico has 3,145 producing and some 615 non-producing (several hundred acres recently having been uprooted for various reasons). Arizona has 1,200 to 1,500 in bearing and around a thousand just set out. Isle of Pines has 2,000 in bearing and fully thrice that area in young trees. Jamaica, Trinidad, St. Domingo, Cuba, and Brazil have a few hundred acres combined. Thus the present bearing acreage of 80,000 to 85,000 may be expected to double within the next four years.

The present world's crop of pomelos is about 10,500,000 boxes. Of this total probably about 1,000,000 are produced outside of United States and Porto Rico, mostly in Isle of Pines, Cuba and South Africa. About four-fifths of the whole crop is sold fresh in the standard two-cubic-feet boxes while the remainder is canned.

The first canned grapefruit was put up in Florida in 1917, but very unwisely they left the white "rag" on the sections and hence in a few days the entire contents of the can became exceedingly bitter. Four years later the canning business started with a rush in Porto Rico and by 1923 both Florida and Porto Rico were crowding every available fruit into the factories, and trying all sorts of processes and formulæ. The canned article now is nearly always very well put up and really much more palatable and convenient for table use. Notwithstanding the enormous amount of canned grapefruit which has been consumed on the eastern states market since 1922, the article is practically unknown in the central and western states. Obviously there is an excellent field for the delicious russet-rinded fruits which the fastidious but ignorant consumer in the North considered second-grade.

The grapefruit canning industry of Florida and Porto Rico now amounts to a $6,000,000 outturn, more than half of which comes from Florida's fourteen canneries. It will increase.

The rind and seeds from the canneries, dried and ground, are a fair-grade cattle feed. Tests by the Porto Rican Department of Agriculture and Labor, both in a by-products plant and in cattle feeding, have indicated that this wasted material should be saved. Grapefruit meal would appear, logically, more wholesome and nutritious than pineapple bran.

Grapefruit peel, candied or in marmalade, seems to be gaining in popular favor. The juice has been bottled successfully, and should become a common beverage.

Efforts to extract the pectin from the rind have failed to eliminate the bitter principle, narangin.

California now exports quantities of grapefruit to the Orient, where there are greatly superior varieties of the sister species, the pummelo.

Pummelo or shaddock (*Citrus maxima*).

There are several types of pummelos in south China, Cochin-China, Malaya and India; no true pummelo has yet been discovered endemic in the Philippines. (Plate VIII.)

The three following characters separate these fruits from the pomelos or grapefruits: The pummelos are more or less pyriform or oblate; the juice-sacs are larger and more loose and separate; the sections are more or less open at the hollow core. It cannot be said that a pink or red color of the pulp marks the pummelos, for several (at least three, probably five) true pomelos are pink-fleshed. A large proportion of the oriental pummelos have flesh of pronounced shades of red, some almost carmine or purplish, like a Blood orange. Generally speaking, these Far Eastern fruits are much better flavored than grapefruit, more aromatic, even spicy; some are fragrant. The texture of the rind varies greatly. Their size runs much larger, up to 20 pounds, as large as a watermelon.

Besides the few excellent varieties introduced recently by the United States Department of Agriculture, only three or four are grown for sale.

The mandarin group.

This group comprises the following types recently separated botanically: *C. nobilis,* the King orange; *C. nobilis* var. *deliciosa,* the common mandarin or tangerine; *C. nobilis* var. *Unshiu,* the Satsuma type, of which there are many varieties though only two or three appear to be known in the Occident.

The King mandarin is, except for outward appearance, one of the very best for eating out of hand. It should be in every citrus grove. It was discovered in Cochin-China in the latter half of the eighteenth century by the Portuguese traveler, Loureiro, and finally introduced in 1880 into California. The story may be true about its having been twice stolen from the palace gardens of a king of Siam; the first thief was tragically unsuccessful but the second got away alive with some budwood. King is the largest of all known mandarins, but perhaps the ugliest in outward appearance; the color is bad, the rind is rough and thick, but the juice of a well-ripened King is very hard to surpass.

The mandarins are worthy of greater attention. There are some exquisite varieties scattered over the Orient, South Africa, and tropical America. Some come true to seed, some do not. Many have a low yield and are short-lived.

The Satsuma group contains excellent fruit, but does not seem to like the tropics.

The lemon (Citrus Limonia).

This old beverage fruit from southeastern Asia is of considerable importance to United States and Italy. The total crop is some 20,000,000 boxes, of which Italy furnishes nearly two-thirds.

The oriental forms of this species have not been duly studied; quite possibly it will be necessary to break it up into several species and sub-species. In the Philippine Islands there are three distinct lemon-like fruits of very limited localization. Only some four varieties are grown commercially.

Cull fruits (scores of thousands of tons) in California are utilized in large factories in the manufacture of citric acid.

Perhaps the most striking new factor in the lemon industry is the recent discovery that the "Meyer Chinese" variety is a very superior commercial lemon in the West Indies. It was found in 1908 near Peking by the late Frank N. Meyer, Agricultural Explorer for the United States Department of Agriculture. This lemon has been grown in city gardens and in houses as an ornamental pot plant (like the Otaheite orange), endures temperatures many degrees below freezing and was at first supposed to be a dwarf variety. In Porto Rico it grows rapidly to a height of 10 feet or more, with a distinct lime-like habit of branching. It is easily propagated (as in China) by cuttings; fruits at two years from setting out, and bears almost continuously and heavily. It is resistant to scab, practically spineless, and of excellent deportment in the grove.

From the commission merchants' viewpoint the Meyer Chinese lemon is somewhat too large—5 to 8 ounces—and the mammillate tip is too small; the juice is superior in flavor but not quite so sharp as in the Eureka or Lisbon lemons. It may not be a true lemon, botanically considered, but appears bound to surpass all limes and lemons for tropical planting.

The citron (*Citrus medica*).

This is the oldest (in literature) of the citrus fruits, dating back to the fourth century B.C. Theophrastus described it, probably from a fresh specimen from some hanging garden in Assyria or Media (whence the name bestowed by Linnæus in 1753). It finally found its way westward to Spain, and by 1640 was reported as growing wild in Porto Rico.

The bulk of the citron crop has been produced for many years in Corsica, Sicily, and Greece. The methods are crude and the mistakes are many but the peasant growers

manage to get a few fruits before the trees succumb to root diseases, frosts, or pests.

About 4,000 to 6,000 tons of brined fruits are marketed yearly. The United States takes about one-third to one-half of the crop. The brine removes the bitter principle of the rind, prevents decay en route, and brings out the unique flavor and bouquet of the peel, which after de-salting and a tedious process of crystallizing, goes on the market as one of the best and most expensive condiments.

There are numerous kinds of citron. One discovered in 1912 on the island of Cebú in the Philippine Visayas smells so good that it was christened *C. medica* var. *odorata* by P. J. Wester. The etrog is a distinct form greatly cherished by the Jews in certain ceremonial rites; for this purpose fresh fruits are imported from Corfu at terrific expense, up to $25 a fruit. Very strange to say, the citron has not thus far been used in hybridizing work, though few fruits hold out better promise.

Sour orange (*C. Aurantium*).

This very widely semi-cultivated fruit is also known as the Seville orange, since the Sevilla district of southwestern Spain produces the bulk of this fruit for the British and Dutch marmalade manufacturers. This is another Asian species, which reached the Mediterranean region before the end of the twelfth century; in Spain it preceded the orange by some 300 years. Even in the Alcazar Gardens in Seville there are three or four fairly distinct varieties of "naranja agria," one hardly two inches in diameter. The Bittersweet orange may be a hybrid with the sweet orange, but it is probably only a sub-species of the sour; it makes a good "ade."

The lime (*Citrus aurantifolia*).

This very old and strangely popular fruit seems to be a cultigen, and was first domesticated probably somewhere in southeastern Asia. Though common in nearly every

tropical and many extra-tropical countries, it has never been cultivated on a large scale outside of three or four islands in the West Indies.

With the possible exception of some kinds of lemons and some of the peculiar citrus of the Phillipines, the various types of limes are the sourest fruits on the market. In fact it is their high citric-acid-content which has made them so widely used, in the belief that this sourness was good for the stomach or blood. A musty-flavored concentrated brand of the juice has for over a century been the standard preventative of scurvy on shipboard.

Dominica, Montserrat and a few other of the Antilles have made fortunes in the lime industry. The juice was concentrated locally and shipped to England or United States in puncheons, or, more recently, made into citric acid in small factories, which are very odoriferous and somewhat dangerous by reason of the sulfuric acid.

During the past decade, a devastating fungus, *Glœosporium limetticolum,* has almost ruined the beautiful hillside orchards; it attacks the flowers and young fruits.

The Mexican, or West Indian, lime is grown under five or six forms from California and the Florida Keys to Brazil.

There are several thornless limes and a few seedless. The old Dominica lime is so seedy, however, that there are over 100 tons of seeds at the factories available for pressing for lime-seed oil.

The so-called Tahiti came from Persia.

The Rangpur is not a genuine lime, but belongs to a nondescript group of Indian citrus. It has a reddish peel and an orange-colored pulp.

Other citrus fruits.

The *calamondin, Citrus mitis,* is a beautiful mandarin-like fruit native to the Philippines, typical of the many unique species endemic there. The bright red fruits are about the size and shape of small mandarins and have a rather loose rind. They remain on the tree three months or so after ripening. On account of their peculiar odor

they may never become popular, except as show trees. The citrologists of the United States Department of Agriculture have used it repeatedly in hybridization work.

The *kumquats* are from eastern Asia, not from Japan, as currently believed. The common oval species is the Nagami, *Fortunella margarita;* the round is the Marumi, *F. japonica;* and the rare Meiwa is *F. crassifolia.* All are nice little fruits, good either for preserves or for eating out of hand; the rind is sweet, the pulp sour.

Kalpi, C. Webberi, is one of the twenty-five or more interesting citrus endemic in the Philippines. Wester calls this a "very variable species"; some forms have juicy acid fruits up to 4 inches in diameter. It is also a promising stock. (Plate VIII.)

Kabuyau, C. hystrix, is another variable species, or perhaps a natural hybrid, of the Philippines. It has roundish lemon-colored fruits, very acid.

Limon-real, C. excelsa, is a mandarin-shaped lemon-like Philippine endemic fruit.

Miaray, C. miaray, is a very rare, but promising species from the wild reaches of Mindanao. It is a good "ade" fruit.

Tamisan, C. longispina, is a rare species native in Cebú and Bohol islands in the central Philippines. The fruit is extra good, but the shrub is almost unapproachable due to the long spines.

Kansi, C. hystrix var. *boholensis,* is a very distinct variety of the kabuyao having oblate juicy fruits and enormous petiolar wings.

Tizon, C. nobilis var. *papillaris,* is a queer orange-like fruit of good promise.

Guyod, C. Webberi var. *montana,* is a very distinct kalpi variety; the rind is extremely rough and corrugated.

Hybrids.

The rough, or goat, lemon, is very common in tropical America and probably came from southern Asia. This rather worthless scraggly shrub or tree has attained much

fame as a cheap, quick-growing, shallow-rooted stock for pomelo and orange varieties. It seems to be a hybrid between the lime or lemon and the citron or some type of shaddock. Its pulp makes a fair "ade," and the fragrant rind a very tasty "dulce" in sirup or glacé.

Sweet lime has been known as *Citrus Limetta* until recently. It is now thought to be a hybrid between the lime or lemon and some fruit like the orange. There are two or three varieties, usually with a rather dry tough pulp.

The tangerona is a rather mysterious hybrid introduced into Florida from Brazil. The fruit is small but excellent.

The Temple orange is probably a hybrid between the sweet orange and some mandarin. The origin is unknown.

There are several tangelos—pomelo with mandarin cross—and a tangelolo, a cross between pomelo and tangelo. They are excellent fruits.

The orangequat is a kumquat-orange cross.

The limequats are interesting little fruits, halfway between the kumquat and lime.

Siamelo is the blended pomelo and King, while the satsumelo has Satsuma blood blended with the pomelo.

The orangelo is a fruit of great promise.

The sopomaldin is a pomelo-calamondin hybrid. This may become a popular pink-rinded grapefruit.

Calarin is a calamondin-mandarin; and calashu is a calamondin-Satsuma cross.

The oranguma is a Satsuma blended with an orange.

Siamor ought to be popular some day. It is the tangelo crossed with the orange.

CHAPTER IX

THE PINEAPPLE

If a line were drawn between major and minor crops at $50,000,000 gross annual value, this most excellent food fruit (the pineapple) must fall into the latter class, but only for the moment. Hardly any other tropical crop has made such a quick and successful entry into international commerce. Its rapid rise in popularity during the past half century has been due partly to its innate worth as a dessert fruit and partly to good fortune and good business management in a certain culture district. Today it competes with the banana, the citrus group, and the temperate deciduous fruits. The value of the fresh and canned pineapple crop of Hawaii, Malaya, and a few centers in tropical America now totals around $45,000,000.

With the exception of Russia and the hinterlands of Asia, the pineapple is more or less in evidence in some form in every country. It is commonly grown in every tropical land and in several regions of Africa it has escaped from cultivation. There are few fruits which surpass it in flavor, very few that are larger, and perhaps none more wholesome.

ORIGIN AND BOTANY OF THE PINEAPPLE

When the Spaniards arrived, the Arawaks and Caribs were beginning to cultivate the "ananás" in the Antilles and in northern South America; it has slowly moved up thither very probably from somewhere in Brazil. A few years ago P. H. Rolfs found in the tableland of Minas Geraes north of

Rio Janeiro what appears to be the original wild form or at least a direct descendant therefrom. It grows in poor dry soils, like its close relative the pinguin, *Bromelia Pinguin,* and the fruit mass has almost no pulp. In the sixteenth century the Spaniards and Portuguese carried slips of this strange new fruit over to the Slave Coast and around to the Orient. The Spaniards pretended they saw in the fruit a resemblance to a pine cone, but the English made a bad matter worse by adding the "apple" at the end. The Portuguese deserve credit for retaining the old Amerind name, ananás.

The pineapple (*Ananas sativus*) is almost, but not quite, a cultigen. The small, scaly, sour fruits, full of the biting crystals (raphides) of calcium oxalate, were carried by the cannibal Caribs on their raids: a few slips or a top left on the beach after a feast of Arawak flesh and the plant was "introduced."

The botanical position or name of the pineapple has had a devious history. Linnæus published it in 1753 as *Bromelia Ananas,* the name Ananas having come into European literature from South American vernacular usage. Subsequently the plant was placed in the separate genus Ananas and it became *A. sativus* (1830), the name under which it is now commonly known. Recently it has been called *Ananas comosus* but it is very doubtful whether this name can hold under the rules of nomenclature. As early as 1754 it had been called *Bromelia comosa* and so appeared in a printed list by one of Linnæus' students, but the name was not published in the nomenclatorial sense, being without description or botanical synonymy. By some writers the plant is known as *Ananas Ananas,* but such duplicate names are not allowed under international usage. For the present purpose, *Ananas sativus* is adopted.

Although the genus has only one accepted species, it is decidedly polymorphic. Some of these variant types are grown as ornamentals for their beautifully striped leaves. No pomologist has ever worked out the synonomy of the

twenty to thirty distinct field varieties. Instead of attempting to amass a complete collection from every tropical country, the largest syndicate of growers in Hawaii has been making hybrids on a large scale, expecting with good reason to secure a dozen or two very superior sorts out of their many thousand seedlings. Eventually the public will enjoy even better flavored "pines."

The so-called fruit is a syncarp, an aggregate of several hundred coalescing fruits, with their thickened rachis, or "core," abortive or normal ovaries, spine-toothed bracts, and the more or less fibrous pulp surrounding the core. This ovate or cylindrical fruit may weigh from 1 to 32 pounds; the usual weight for canning fruit is about 6 to 10 pounds in Hawaii, where the Smooth Cayenne is planted, or a little over half that size in tropical America.

The apparently stemless plant usually stands about 3 feet high; in good soil some varieties may reach 6 feet. The long, narrow, grayish leaves are, except in two or three varieties, armed with short sharp spines along each margin. The rather weak stem bears ratoons, suckers and slips at the base, middle and upper part, and propagation depends on these. The leaves of some wild forms used for the fiber may reach a length of 9 feet or more.

REGIONS GROWING PINEAPPLES

In 1555 the French botanist, André Thevet, brought the American "Nanas" to the attention of the European public. It appears, however, that the fruit was in the form of a preserve with the raw brown West Indian sugar; anyhow the flavor was new and delightful.

The Dutch, naturally, were the first to attempt the cultivation of the fruit under glass. By 1690 the English were enthusiastically growing it. Then the Canary Islanders found that European epicures were willing to pay fancy prices for all they could produce.

Singapore was the first to succeed in canning the fruit, some thirty years ago. Some of the finest and largest

"pines" in the world are still produced in Borneo and the Malay States.

Florida was, some twenty-five years ago, a famous "pine" producing center. Then the business passed to Cuba and Porto Rico where the industry still continues, strongly in the latter island. Costa Rica is competing for a place in the trade. The largest tropical American field in one block lies in the ideal soil between Cristophe's Citadel and the site of Columbus' first settlement at Cape Haitien. Ceylon, Madagascar and Queensland also are interested in growing pineapple. Hawaii, however, turns out about 75 per cent of the total.

On the whole this crop is one of the safest, provided the site is well chosen and the market fair. The turnover takes only about twelve months. The cost of production is comparatively low. Pests and diseases are seldom very serious. Soil troubles can now nearly always be controlled.

Outside of Hawaii the yield is generally around 300 to 400 crates to the acre; thus the gross returns may vary from $200 to $2,000 an acre.

There has been no great boom in the industry since about 1917, when the remedy for chlorosis (iron starvation) was discovered. There will be, it is expected, a steady increase in the output of the canned fruit, and the quality of the Hawaiian product may go up when the new hybrid varieties come into bearing.

CULTIVATION OF PINEAPPLES

The pineapple planter must guard particularly against insufficient drainage, excess of lime (in tropical America) and excess of manganese (in Hawaii).

Since nearly all bromeliads are "air-plants," it is natural that pineapple roots are water-shy and weak. In stiff clay soils they are likely to form balls by growing around and around the stem base; in rich moist land they develop various fungous troubles or simply suffocate. Loose light soil is best for pineapples; black in Hawaii, red in

West Indies, or white sand in many countries are all the same, provided neither free lime nor iron-holding manganese interfere. There must be a reasonable amount of humus, however, natural or applied. There must be either a slope or a good depth of the loose earth for vertical drainage, or else the plants must be set up high on raised beds. The pineapple can endure a shallower soil than any other crop except, perhaps, vanilla.

A rainfall of 30 to 60 inches suffices for this crop. The sinus at the clasping base of the leaf is a valuable asset to the plant: dew and rain run down the gutter of the concave upper surface to the reservoir next to the stem. The pineapple can thus go through a drought that would kill most crops.

If the soil looks purplish and shows more than 3 per cent manganese, there is danger that the iron will be withheld from the plants which will then become pale and sickly, unless they are sprayed with iron sulfate.

The lime problem in tropical American plantations is very perplexing. A field may do very well at the foot of a coral hill while a mile away another field may show serious lime sickness. Presumably humic acid and various chemical reactions in the soil may upset the lime balance somehow so that the sensitive "pine" roots suffer.

Pineapples do not tire the land much. There are fields in Porto Rico which have been in "piña" for at least several decades; and in Liberia there are areas where the naturalized plants have held back the jungle for probably half a century. On the other hand, growers apply rather large quantities of high-grade chemical fertilizers; if intelligently done the growth and the fruiting can be fairly well controlled by the opportune application of the correct formulas.

The pineapple is practically free from wind damage. However, in light dry soil young plants are likely to have the sinuses of the lower leaves choked with the drifting sand, and in some unexplained way this retards the growth. Cot-

tonseed meal is frequently dropped into the leaf-axils of young plants; this forms a wad which keeps out the sand and as the leaf elongates it carries outward the adherent mass.

These sinuses in the leaf-axils have several advantages to offset the drifting-sand nuisance. To force the immature plants into rapid growth, sulfate of ammonia and other fertilizers may be dropped into these reservoirs whence the plant absorbs the chemical directly into its circulating sap. This practice of feeding fertilizers straight into a plant's tissues is used only with pineapples, it seems. The sinuses also collect dew.

In the past three years considerable attention has been drawn to a special kind of thick paper which, laid off in 36-inch (some 24-inch) strips with 5½-foot spaces between, is used as a blanket for the double rows. One company lays 4,000 miles of it a year. There are three grades. This paper does three important things: it prevents the growth of weeds and grass around the young plants; it retains heat and moisture; and it prevents loose earth from drifting into the leaf-pockets. Holes made by thrusting a stake through the paper *in situ* allow the seed plants to be set and gently but firmly held in position at just the proper depth while they are striking root.

The large varieties, like the now famous Smooth Cayenne, are planted in double rows; by setting the seed plants rather close (20 inches, usually) in the row, with the rows 18 inches apart, and by leaving barely room between the beds for the pickers to pass through when the plants attain their full 4 or 5 feet stature, some 7,468 sets are put into an acre. About 8,000 to 11,000 plants of the smaller West Indian sorts, Red Spanish, Sugarloaf, go to the acre; three or four rows make a bed. Picking the inner rows when the very spiny leaves reach up and out 3 or 4 feet is not very pleasant, but fortunately the scratches made by the spines seldom cause any real trouble.

To cut the weeds among the plants a special implement

had to be devised, the scuffle hoe. The blade is set nearly parallel with the handle, so that it can be thrust in between the stiff criss-crossing leaves.

No shade is allowed and no cover-crops are needed. Grass is the principal menace to the young plants.

One of the most striking examples of applied agronomic chemistry is the simple remedy for the iron-hunger disease of pineapples in manganese soils. About 1916 the anemia trouble was gradually becoming so severe that the industry was suffering in Hawaii and many plantations were abandoned. Several research experts set to work and two institutions finally found a way to give the suffering plants their due ration of iron: priority of discovery was claimed by the Federal Agricultural Experiment Station. Since the iron was withheld from entering the soil solutions by some subtle chemotaxis, the roots were powerless to obtain the small but necessary daily dose. After many trials, it was found that a weak solution of ferrous sulfate sprayed onto the leaves was readily assimilated and the effect of the iron on the chlorophyll was noticeable in one or two days. Ten cents worth of green vitriol sprayed onto an acre of the affected plants resulted in an increased yield of fruit to the amount of about $100. The iron sulfate spray is being regularly used on approximately 40,000 acres of pineapples in the Hawaiian Islands.

PROPAGATION OF PINEAPPLES

There are five ways of propagating pineapples. Beginning at the bottom, the old stem or stump, after the terminal fruit is cut, may be chopped up into sections a foot long and set (like sugar-cane cuttings) loosely into the earth with one end protruding. For several technical reasons this method is not popular.

The second method is by the vigorous bottom ratoons, springing from the base of the old stem. These are usually too few for continuing the plantation, but when they are not too leggy they may be left in position for two, three,

or in rare cases five or six years, giving a fair crop with no planting expense. When removed and set in new rows, they should yield a crop in twelve to fifteen months.

Higher up the stump the suckers, or stem slips, appear. These are stockier but smaller, and may be graded into two or three classes. These give fruit in about a year from setting; they keep and carry well, and are the standard "seed." Just below the fruit, in a more or less crowded whorl about its base, are the true slips. These, being much smaller and weaker than the suckers, require longer to make fruit, fifteen to twenty months under average conditions. They are second choice and much cheaper, but quite reliable. Some varieties produce few or no slips, others up to a dozen.

The head, or top, can be and frequently is used by novices; but the adherent pulp, in rotting away, leaves a danger area and many months may pass before a single root puts forth. About two years are required for fruiting.

Finally, there are the seeds, at least in most varieties. Even when produced, the small brownish seeds seldom germinate well. To carry the delicate seedlings through the first two years is a tedious task. With good luck the new variety of fruit may appear the third year, but probably it will be five or six before the hybridizer, presuming that two varieties enter, can know whether the seedling is worth giving a second chance to fruit. The percentage saved is deplorably small. Pineapple seedage was instituted by the United States Department of Agriculture some twenty-five years ago. A number of very superior varieties were created, spicy, aromatic, almost fiberless, one with practically no core; but it appears they have been lost sight of. About fifty varieties are needed whose qualities should range more widely in size, sweetness, fiber-content, color, bouquet, hardiness, than those now under cultivation.

VARIETIES OF PINEAPPLE

While 90 per cent or more of the world's output is produced by four varieties, there are at least fifteen quite

distinct sorts, not counting seedlings and teratological freaks, double-fruited, cockscomb-topped, and the ornamental striped-leaf varieties. There may be quite a number of insignificant forms of the semi-wild varieties; and there are probably a few very obscure kinds of the long-leaf fiber form, or sub-species.

The following are the commercial sorts:

Smooth Cayenne is the "pine" which made Hawaiian pineapple famous to the extent of about $250,000,000. According to name it should have come from French Guiana. It behaves well but is popular only in Queensland and Hawaii. It is a rather large stocky plant with bronzed leaves having hardly a spine on their margins. The fruit, however, is not very handsome and a bit coarse, but it cans well. It requires considerable feeding. (Plate IX.)

Red Spanish is a hardy, rather small variety of uncertain origin. It will grow almost anywhere except in a swamp, and 95 per cent of the plants, 8,000 to 10,000 to the acre, will bear salable fruits. The fruit is decidedly below medium in size, running from 16 to 48 to a crate with the bulk about 24 to 36. It is not a sweet "pine," but when ripened in the field it has a high flavor. It is the best shipper.

Cabezona is an old Porto Rican "pine" which vies with the King as the largest. It was grown rather extensively in the southwest-central district of the island a quarter of a century before the American occupation; and it is still used in high-grade canning there. It cannot stand shipping; the weight crushes the eyes, and bruises mean fermentation instantly. The run of the fruits is around 10 to 15 pounds but many go over 20, and one was reported to tip the scales at about 32 pounds, the world's heaviest multiple fruit. The flavor is good, but not the best. The plant may reach a height of 6 feet or more. Some of the bottom ratoons may bear fair-sized fruits while attached to the mother-plant.

Sugarloaf, or *Pan de Azúcar* as it is called in Spanish

America, is excellent for eating out of hand. The Singapore "pine" is similar and exceedingly popular in the Orient. The Caraqueña, or Venezuelan Sugarloaf, is rougher on the outside, but delicious within. The plant is medium-sized, the leaves usually showing a reddish tinge. The fruit is highly colored, long or conical, like the old-fashioned "pilones" of sugar (whence the name). The pulp is yellow, very tender, and very ripe specimens can be eaten with a spoon.

King is a rare variety, supposed to have originated in Borneo. It is perhaps as large as the Porto Rican "Big Head," or Cabezona.

Negrita is a semi-cultivated very dark-fruited variety of the West Indies. There are several kinds of *Ripleys,* all long-pointed or cylindrical fruits of exquisite flavors and a rich sweetness of juice. The plants are accused of being too delicate and rather shy bearers. The *Ruby, Bullhead,* and *Black Antigua* are rather rare but high-grade West Indian pines.

PESTS AND DISEASES OF PINEAPPLE

This crop has comparatively few serious insect pests. Several species of scales are troublesome in some districts. One mealy-bug not only attacks the roots, stem and leaves but even enters the eyes of the fruit.

A much dreaded red-spider, Tetranychus sp., really a true mite, just visible to the naked eye, plays havoc with the leaf-bases in many localities. Nicotine sprays and dusts help—as does also rainy weather. This worst of all "pine" pests is of late accused of being the carrier of a very serious new disease—probably bacterial—the etiology of which is being studied.

In some localities rats damage ripening fruits. The barium treatment appears to be the best. A few species of nematodes nibble the roots where soil conditions permit.

A new fungous disease has appeared in Queensland,

PLATE IX.—A vast field of Smooth Cayenne pineapples, Cape Haitien, Haiti. Nearly every plant (5 feet tall) bears a fruit; Hawaiian culture system.

another in Hawaii, and a third in Haiti. Any one of these appears capable of giving the industry a set-back if not kept under control.

Six species of fungi attack field plants and several others cause fruits to rot in the crates.

It is theoretically possible for mosquitoes to breed in the axillary sinuses of very large pineapple plants. In fact, the wild relatives of Ananas, which grow on the branches of jungle trees, not only harbor mosquito larvæ but even their enemies, dragon-fly larvæ.

THE PINEAPPLE CANNERY BUSINESS

When Singapore began canning pineapples in the nineties, there were few machines in the factory. By the time Porto Rico and Hawaii started to compete, about 1903, there were several types of apparatus which reduced greatly the amount of hand-labor. Recently the famous "Ginaca" machine has revolutionized the handling of the fruits in the factory. This machine grasps the fruit, cuts off both ends, takes out the core, forms a pulp cylinder of just the correct size to fit the can, and then (more difficult by far) grates off the pulp from the inside of the peel sleeve, sending the cylinder to a special slicing machine, the pulp from between peel and cylinder to the grated tank, and the peel itself to the dryers for making into bran. All this occurs in two or three seconds, 60 to 100 fruits being handled by each machine every minute.

The chemists and engineers of the canneries have made great progress during the past few years, perhaps excelling those of the vegetable and temperate fruit factories. They have stopped many leaks and saved quite a few millions for the business. Today this business runs into a figure well over $30,000,000 (about 190,000,000 cans) and will go higher.

The juice, which used to be wasted, is now filtered, treated to remove the citric acid, sweetened, and added to

the slices in the can. The citrate by-product goes onto the market to improve the fastness of colors of calico and to enliven commercial lemonades and other drinks requiring a wholesome sourness.

Until the last few years the trade wanted only slices in the cans, but by dint of a thorough advertising campaign there has now grown up a strong demand for the grated pulp.

The juice does not stand regular cooking well, but a very delicious sirup, a little off color and with a little tang, however, can be turned out very cheaply from the waste juice from the peeling and slicing tables. The thin juice can be bottled as such, or concentrated, preferably *in vacuo,* into soda-fountain stock. Surplus juice goes into vinegar or alcohol.

Recently the Hawaiian canneries have begun to utilize the peels. De-pulped, dried and ground, this waste material becomes "pineapple bran," a fairly good and cheap cattle and pig feed, though somewhat rough.

The fruit, well ripened on the stump, contains anywhere from 10 to 15 per cent sucrose. The juice, about as sweet as sugar-cane guarapo, or stem sap, ferments very quickly; and in many places this liquor is unfortunately popular: it seems to contain an unwholesome element. In Portuguese East Africa the aborigines make a terrific brandy (in crude stills) from this fermented juice. The stump contains starch but it is bulky, will not dry for burning in the field, and cannot well be buried.

The leaves are full of a hard, white, brilliant fiber. Machines and processes have been invented to extract this valuable by-product, but, to date, the planters think it more practical to burn when possible or haul the old stumps and leaves off to the dump heap.

In Malaya, Brazil, and the Philippines long-leaf varieties are grown in partial shade, and the fiber, hand-stripped by a slow tedious method, is a textile material of considerable value. Half a century or less ago a large part of the better

Philippine domestic fabrics was piña, and many of the choice grades were and are among the very best cloths in the world. They had the sheen of silk, the firmness and strength of linen, and almost the durability of spun gold. No other fabric can endure fifty years of tropical humidity.

CHAPTER X

THE BANANAS

Only the coconut is more important than the banana as a food fruit or more widely known. There is probably no tropical country today, except the Sahara, where some form of Musa is not used for human food. However, the general public is familiar with only one variety out of the 300 or more. Five varieties are obtainable in the United States, two in Europe. In most tropical American markets one can buy from five to fifteen sorts nearly every day in the year, and in some parts of the Orient this number could be doubled.

Recently a powerful syndicate has awakened to the urgent need for assembling a representative collection of the world's best bananas and plantains from which later a number of varieties can be selected for commercial exploitation. Not many years ago plant-breeders, especially in Jamaica, began creating new varieties by cross-pollinating wild African with the old plantation types.

No other fruit, perhaps, is misused by so many people and none other has aroused such controversies about its dietetic value. One expert maintains that it would take about eighty average-size fruits to furnish the daily caloric needs of an average individual, while another shows how whole tribes in central Africa live largely on plantains and that eight fruits a day would be a feast. Raw, it is declared to be "useless in the digestive tract"; baked or fried, "a disease-preventing, high-grade food."

In commerce the banana crop is worth only some $40,000,000 a year, dock value of exported fruit. In scores of thou-

sands of kraals, kampongs and pueblos throughout tropical Africa, Asia and America, however, the cash price should not be reckoned but rather the home value without which millions of families would find life rather precarious.

DESCRIPTION AND HISTORY OF THE BANANAS

The genus Musa, with about fifty species, is the only important one of the six genera of the Musaceæ. This family stands close to the small Cannaceæ and the large group of Zingiberaceæ; the Lily family is related. It is well here to adhere to Linnæus' differentiation of the bananas as *M. sapientum* and the plantains as *M. paradisiaca,* but it must be remembered that there are many connecting forms between these two, and *M. sapientum* is usually considered a variety of *M. paradisiaca.* There are many species or kinds of Musa, the genus to which the banana belongs.

The greatest numbers of species are found from south China down through the Philippines. where some twenty interesting kinds are endemic, to the East Indies and Queensland, then eastward across the Pacific and westward to the mountain fastnesses of the great Deccan Peninsula. Some have dry, pulpless, seedy fruits, others have a fair amount of scented jelly surrounding a few small seeds.

Description.

Aside from the bamboos the musas are the tallest herbs and the largest woodless plants. A specimen of *M. Ensete* may weigh 5 tons, and stand over 35 feet high. By means of strong and very long fibers running from bulb-like base up through the leaf-bases to the blades, and by wrapping all the prolonged leaf-bases together into a straight cylinder, the musas have been able to hold their leaf-blades and inflorescences well up above the underbrush without any solid structures whatever in this false-stem. Some species have no trunk; *M. ventricosa* of Angola has a short swollen stem 4 feet in diameter.

The base of the midrib is gutter-like and runs into a channeled petiole which forms a sinus reservoir where its free portion joins the pseudo-stem. Thus dew or rain flows down into this petiole tank and, being partially inclosed, does not evaporate rapidly; in fact, one of the largest species of mosquitoes in Manila uses these sinus cups for breeding grounds. The Ravenala, or traveler's palm, a close relative of the musas, has larger petiolar sinuses which are always full of water.

The terminal inflorescence forces its way up through the center of this petiolar bundle. In six or eight species the rachis, or main peduncle, stands erect above the crown of leaf-blades at the top of the pseudo-stem, but in most kinds the peduncle bends downward, though the fruits bend upward: nearly everyone nowadays knows that the grocery-store bunch hangs bottom-end-up.

In the common varieties the first few clusters of flowers which open at the base of the rachis are female, and these, without being affected much, if any, by the pollen from other flowers (borne by bees and humming-birds), set as "hands" of fruit. In most bananas, but not in most plantains nor in the common Chinese banana, the flowers along the middle portion of the fruit-stem are hermaphrodite (both sexes in the same flower) but do not set normal fruits. The flowers toward the tip are much more predominantly male, though the pollen is probably in few cases viable for the stigmas of the female flowers of its own variety. These terminal male flowers never have time nor strength to finish opening, one bract at a time, before the fruits at the base ripen; this conical bud of the unopened flowers is slashed off at the time the bunch is harvested.

The flowers contain considerable nectar. Humming-birds get it readily enough, as do the long-tongued sphingid moths. Bees, however, have great difficulty in reaching it unless the flower hangs so that the nectar runs down to the mouth of the perianth.

Some musas have edible roots. Some are fiber plants,

like the Philippine abacás. In some species the whole flower- or bunch-bud before it emerges at the crown is eaten as a cabbage. In the Philippines the "pámpano," or terminal flower-bud, is boiled or roasted and its core eaten as a salad. The young leaves and the central portion of the stem are fair pig and cattle provender.

The banana is potentially a root-crop. In Abyssinia today the huge fibrous bulb-like base of *Musa Ensete* is used for food. Pedigreed sires on model farms of the Insular Department of Agriculture and Labor in Porto Rico have fed on banana-bulb meal.[1] Quite possibly, as O. F. Cook has suggested, the big starchy root of the wild dry-fruited species was first used by hungry savages, who later and very gradually and even unconsciously, perhaps, bred out the seeds and bred in the pulp. Even now, after thousands of years of domestication, every banana fruit shows traces of abortive seeds; and several varieties on the Manila market occasionally contain viable seeds as large as a small pea.

History.

Probably 3,500 years ago these very popular fruits began their westward way. Alexander's army found bananas in the Indus Valley in 327 B.C., growing with cotton and mangos in vast fields. Assyrian bas-reliefs show plants which seem to be bananas, which means that they had become very important by 1100 B.C. In Arabia they made a great impression on the intellectuals, like Ibn Said (known later as Avicenna) and Rhazes. Unfortunately the reputed derivation of the botanical name from the mythological muses is merely poetic. The name is in honor of Antonio Musa, physician to Emperor Augustus.

In 1516, the Spanish Friar Tomás de Berlanga found the semi-civilized inhabitants of the Canary Islands depending to quite an extent on these fruits instead of on barley

[1] This meal contains (at a 10 per cent moisture state) protein 4.7 per cent, carbohydrates 70 per cent, fiber 8.3 per cent, and ash around 5 per cent or more.

as they had done a few generations before. Seeing their potential value for the colonists in the Antilles, he carried a few roots that year over to Hispaniola, and it was probably from Friar Berlanga's roots that plants were well distributed throughout the West Indies before 1550. Both the theories as to the arrival of bananas or plantains in the Canaries are somewhat improbable. The possibility of the local origin of these species may be disregarded. Therefore, they must have come from India, perhaps via Arabia, either across the Dark Continent or around the Cape. It is a question whether savage tribes passed them on from one to another over, say 4,000 miles of very precarious traveling, or whether the Phœnicians or probably the Portuguese somehow managed to get them down the east coast and up the west, presumably after Vasco da Gama's eleven-months trip in 1497. Against this fairly plausible explanation is the fact that the learned Portuguese pharmacist, Garcia da Orta, made the voyage around the Cape in 1536, never returning. He reported several similar names which the natives of the Guinea Coast applied to these fruits,—banana, bonano, banema. He found the same sort of fruits, cultivated of course, when he went ashore at Sofala in the northern part of what is now the colony of Portuguese East Africa, and these Mozambique "bananos" were of very good flavor, quite likely of a different variety from those he had eaten several months previously on the opposite side of the continent. They could hardly have worked around through the Mediterranean region. Egypt had none. To penetrate a barbarian agriculture and acquire a series of similar-sounding names must have needed much more than the thirty-eight years between da Gama's and da Orta's trips.

It might be argued that the Arabs or Moors had managed to get down the west coast by the twelfth century, but to offset any idea that the Guanches had been given plant presents by any neighbors on the north are the historical records of nearly 100 years of as desperate fighting as the

world has ever seen, before the Spaniards (about 1491) conquered the terrible Guanches.

Humboldt and Acosta were clearly mistaken in thinking that the Incas may have known some sort of banana. Harms [1] authoritatively dismisses both the plantain and the banana from prehistoric occidental agriculture.

There is an historical note by Oviedo to the effect that early in the sixteenth century a boat sailed into the Gulf of Paria, separating Venezuela and Trinidad, and sent a part of the crew up a great river to obtain a supply of some fruit, apparently the banana. If, as many believe, traders from west Africa had been doing quite a business with tropical America for a long period before 1492, they may have brought over plantains as well as cottons and yams and established them for their own re-victualing and outfitting purposes.

In short then, the economic musas from some center in southeastern Asia spread eastward into Polynesia and westward into India; how and when they reached west Africa is, and will probably remain, a mystery; but from the Canaries they were introduced into the New World in 1536.

CULTIVATION OF BANANAS

The banana requires a fairly humid climate, moist deep rich soil with perfect drainage, protection from wind, full sun and much heat. The roots cannot penetrate hardpan and hate rocks; they will endure some clay if there is no danger of sour soil or stagnant water.

On account of their top-heaviness the large heavy leaves, to say nothing of the bunch of fruits, weighing 50 to 75 pounds, bananas are often blown down. The blade has several hundred side veins running straight out at nearly right angles from the midrib to the margin of the lamina; the parenchyma between these side veins is too weak to stand the strain of the sail-like flapping of the blade

[1] Harms, Heinrich, "Study of the Remains of Plants in Peruvian Tombs."

in any real wind; the tattered older leaves are unsightly and, of course, cannot accomplish the full amount of photosynthetic work as an entire leaf. Therefore, the planter should provide either natural (hills) or artificial (windbelts) protection from winds. Leguminous trees, at least 25 feet high, planted close in narrow hedges, as described in Chapter I, are recommended.

There are three kinds of seed stock. Depending on soil, season and need for haste, the planter may select sword suckers, palm suckers, or root chunks. The almost leafless side shoots from the mother bulb, starting a foot or more below the soil surface and standing nearly vertical near the base of the old plant, say 2 to 3 feet high, are the best for most cases. These swords can be cut off from the stem base with a sharp spade or broad-pointed cutlass without much digging, and then a strong wrench pulls them up, unless the soil is heavy or roots have started to grow. Usually their very pointed tips are slashed off, before or after setting in the holes.

The broad-leaf or palm sucker is an offset arising very close to the old stem bulb and near the soil surface. They bear a few leaves at the tip and may be 3 to 6 feet tall. They should be cut back to about a foot above the corm. The old bulb may be dug up and re-set whole or split into halves or quarters. Full sun weakens the seed roots, but bleeding is checked and decay prevented if the cut surfaces are quickly dried.

Ordinarily the "seed" should be set within three or four weeks. If thrown into heaps and lightly covered or shaded, however, they will slowly begin to sprout and hold over two or three months—after which the sprouts may become too large. Carefully dried and packed sucker bulbs of a pound or so weight have been sent by mail from Porto Rico to the Philippines without losing much vitality.

The true seeds may be used for propagation, but they generally give poor germination and the seedlings are slow growers at first. One variety in the Philippines, "La

Virgen," apparently never produces any offsets from the old bulb. The 30-foot *M. gigantea* has the same habit.

The field should be plowed, but this is hardly possible if forest has been felled and burned to make a "walk," as called in Jamaica. There is not much use in planting bananas where there is any danger from grass; vines and jungle growths are bad, but grass and sedge are worse.

Broad holes, not very deep, are best for bananas, partly re-filled with trash and surface soil. The dwarf Chinese, or Canary, banana may be set 10 x 10 feet or even 8 x 8; in medium soil the common Jamaica, or Gros Michel, requires a distance of about 14 to 16 feet each way; when the stems tower up to 20 feet, as in the rich soil along the Chagres River, 18 or 20 feet is better. The Keith system, sometimes used in Central America, consists in planting in blocks 25 x 25 feet, 4 plants to the block and 4 feet apart. Outside the plantations of one large company, however, there are very few bananas in rows.

Cowpeas, sword beans, or beans, may well be planted about the young plants to keep down weeds. Between the rows there may be planted sweet potatoes, cassava, yams, maize, pigeon peas or some light catch-crop which will be out of the way in nine or ten months; maize almost always finds a fair market outside the plantation, the others are largely consumed locally.

In dry situations harrowing or cultivating to make a dust mulch is expedient.

Like coconuts, coffee and cacao, the bananas and plantains are practically never fertilized. They respond promptly enough to either chemical or stable manures, and where the cut-off fruits are worth $2 a hundred, as in some districts in Porto Rico, a few planters recently are profiting by money spent in potash and phosphate. How to apply the fertilizer is perhaps more important than what kind.

Once probably the first year and twice or thrice each succeeding year the surplus suckers should be pruned off to throw more strength into the fruiting stems. Long before

the first flower-bud pushes up slowly through the center of the stem, several side shoots burst up through the earth around the main butt. It requires long experience to know which suckers to cut off and kill. An expert pruner can regulate the time of the fruiting of the second, third, and fourth daughter stems. Details would hardly interest the general reader, but banana pruning is one of the most difficult tasks in tropical agriculture. Various tools for pruning off the supernumerary offsets have been invented, but the long-handled spade and machete still do most of this work.

In the Canary Islands, the dwarf Chinese banana is never grown in vast fields like the Gros Michel plantations, but rather in well-tended terraces and small patches. In Fiji there are some fair-sized fields of this Canary variety. In the Orient plantains or bananas are scattered far and wide in every nook and corner, millions of them—of fifteen or twenty species and ten times as many varieties.

HARVESTING BANANAS (PLATE X)

Picking is heavy work. Ten or twelve months from setting the first bunch should be "full." Only trained hands can tell just when the bunch is fit to cut; not so much the color as the look of the angles on the basal hands and the way the fruits begin to crowd each other reveal the secret. In ordinary ground the picker can reach about half way up the stem with his cutlass and a slanting blow which cuts off half or three-fourths of the stem, topples over the upper portion and sways the heavy bunch gently down within his reach; after catching the bunch by the bare part of the rachis between the lower hand and the purple bud at the tip, and slashing off the base of the peduncle near the curve where it bends back downward, the bunch is dropped carefully onto the ground or passed to a helper who carries it to a near-by pile. Among large plants two men work together; one jabs a broad-edged lance into the stem at such a height that when it folds down from the cut the bunch

can be caught by the two men before it can touch the ground, and a short blow with a sharp knife severs it. One of these pickers or perhaps a third laborer then attacks the old stem and chops it into several sections which are left to rot on the ground where they fall. The stump should be left 2 or 3 feet high, and later it may be dug out with a curved-bladed spade. At this time or later, perhaps, the old dead leaves, hanging down around the stems and cluttering up the stool—which may contain four to eight or ten stems in various stages of growth—should be cut (not pulled) off and thrown out away from the clump, to avoid calling the roots up to the surface.

Donkeys, mules, hinnies, horses, women, or men carry the bunches to cart roads or narrow-gauge railways; the latter take small cars, in many plantations twenty-five to fifty bunches to the car. Usually small locomotives, steam or gasoline, haul train-loads down to the shipping point. A bunch, picked at sunrise or "before coffee" back in the dew- or rain-soaked valley head, may find itself before midnight, with 20,000 others, on the canvas belt running over the clicking counting apparatus (which keeps exact tally of every one) into the cooled, but not cold, hold of a banana boat.

The banana crop is fairly dependable, except for the attacks of two terrible pests. In medium land the common Jamaica banana should yield about 200 bunches the first year of bearing, beginning ten or eleven months after planting. If all goes well there ought to be about 300 the second crop year, with little or no diminution in size. The third year's outturn may be of poor quality, small bunches, but there should be 300 to 400 bunches. If there is no "Panama" disease and no root-weevil, with good weather, few weeds and good men on the pruning work, it may be profitable to keep on picking for six or even ten years. Hundreds of fine plantations, however, are abandoned after three years and, instead of at once putting in some other crop, such as cacao, coconuts, coffee, cotton, cassava, to hold the ground,

the poison-excreting grass roots are usually allowed to take possession, then the jungly weeds and shrubs and finally the trees come back, all in four or five years.

PESTS AND DISEASES OF THE BANANA

Aside from the banana wilt or "Panama disease," comparatively few fungous and bacterial diseases attack any of the musas. In 1903 the writer first noted a few sick plants in a collection of bananas at the Agricultural Experiment Station at Mayagüez, Porto Rico; beginning in the solid rhizome and running up through the center of the pseudo-stem there was a mass of rotting ill-smelling tissue, believed to be caused by bacteria. A few years later this disease was reported as a serious trouble in several other regions; by 1910 it was spreading throughout almost all of tropical America and many thousands of dollars were spent in the effort to check it. Since the organism (*Fusarium cubense* described by E. F. Smith in 1910) works underground and probably always enters the root first, sprays are useless. Digging up the stool and trying to burn huge wet bulbs may, unless very great care is used in disinfecting the tools and even the shoes or feet, only serve to spread the infection through the field. A stool once attacked may continue to produce a few bunches, but usually all the stems succumb within a few months. Banana wilt has cost millions, and it will cost more. There seems to be no way to stop it. Fortunately the Chinese banana and the plantains are more or less immune; and there are certain strains or sub-varieties which are seldom attacked.

In the Philippines there is a peculiar fungus which works inward, instead of from the heart toward the outer sheaths; theoretically a bordeaux spray might at least prevent its spread from one stem to another close by.

The root-weevil, *Cosmopolites sordidus*, has followed the bananas around the world and, while it does not like cool temperatures, high altitudes, nor clayey wet soils, there are few regions entirely free from its terrible depredations. It

enters at any weak point on the rootstock, burrows in toward the softer starchy center, and the footless whitish grub, an inch long, after three weeks tunneling, pupates in the burrow, emerges after a week or so, walks about, mates, and, by the second or third generation, that clump of bananas is too weak to flower. This deadly enemy of all the musas is really one of the most important, though usually much underrated, negative factors which tend to retard the development of the tropics; like its cousin the sweet potato weevil, it raises the cost of provisions for the laborers' families.

The ripe fruits are attacked by rats, birds and, in the Orient, by the fruit bats. The tender young leaves and the top of the stem are relished by deer, cattle, and elephants. Probably fifty or more distinct varieties have been exterminated in the last fifty years by wild or half-wild cattle, goats, and pigs roaming about the mountain slopes of most of the larger islands in the Pacific and Malayan archipelagoes; a dozen sorts in Hawaii alone have literally been eaten down to the ground.

SPECIES AND VARIETIES OF MUSA

The synonymy of the musas, with the 300 to 400 varietal names applied to the bananas and plantains, can never be worked out scientifically until a growing collection is assembled. This the author attempted to do in the Philippines in 1912. Hundreds were brought together from Ceylon and Siam, from Japan and Tahiti, the back districts in Papua where no white man goes, the Congo Valley, through the two Malayas, even to the interior of Mindanao where grows the giant abacá. At "No. 735" the work was interrupted, just when extremely interesting results were coming. A surprising number of new species were described from the assemblage after it was broken up in 1914 to 1919.

Very briefly the taxonomy of cultivated musas may be summarized:

Musa paradisiaca covers the true plantains.

M. sapientum includes most of the bananas, of several sub-species.

M. acuminata includes the beaked pisangs, or short, angular, pointed bananas of Malaya.

M. corniculata is the lubang of Cochin-China and Malay Islands; said to be native to a dense forest in western Luzon, not far from Manila.

M. Cavendishii is the Chinese or Canary banana; there are several forms.

M. Fehi takes in the very interesting fehis of the Pacific archipelagoes: violet sap, erect bunches.

M. troglodytarum includes several forms, wild or semi-cultivated in the Middle East; peduncle erect at base but curving back in upper half; apparently not related to *M. Fehi* but rather a sub-species of the plantains.

The plantains.

The plantains deserve to take precedence over all others in the family; for centuries they have fed many races of people in many lands. In historic times these fruits have not been propagated from seeds, since very seldom do any of the fifty to seventy-five distinct sorts in general cultivation produce viable seeds. Many of the varieties have probably originated as bud sports; but presumably there were several wild species whose blood has spread through the group. The following empirical method for securing seeds is recommended: Plant two hills where they have a good chance to prosper; let them alone for two years, no pruning; in the third year slash down all but one fruiting stem on each clump; if some of the pistillate flowers at the base of one bunch are receptive to the pollen from the staminate flowers of the other, there may be formed a few real seeds.

Tonduk, or common plantain, is the usual type throughout tropical America, where it is known as the Hartón, Macho, or Amarillo Plátano, and in the Orient it is one of the widest grown sorts. The plant is about half or two-thirds the size of the Jamaica banana; the leaves are paler;

the terminal flowers, as in most of the members of this species, hang, a shriveled cluster, close up to the distal fruits in the bunch. The bunch may contain fifteen to fifty fruits in three to five hands, loose and spreading; a medium-sized fruit is 9 to 12 inches or more long including the rather abruptly tapering base and 1 to 2 inches of the prolonged tip, weighing about twice to thrice as much as the average Jamaica banana. The pulp is more or less salmon-colored and firmer than banana pulp. When dead ripe the plantain may be eaten raw, but its cheesy gummy texture and slightly acid taste render it unpopular for eating out of hand. Packed away in a sack or barrel for a week or so, the green skin—picked before turning yellow, of course—turns a dull brownish-yellow and finally blackish. Then, fried or baked, it becomes a most wholesome addition to the noontime meal: a slightly acid or vinous flavor with no danger of cloying, it can be eaten, like the potato, every day with no danger of growing tired of it. If cooked before the peel darkens completely, the "fécula," as it is called in Spanish, the interior of a starchy fruit or root, is golden-brown and dry; at this stage it goes well in stews and soups. Baked whole or fried in slices or roasted, it appears, with rice and beans, on many tables in tropical America and the Orient.

Sliced just at the turning yellow point, dried in the sun, and ground or pounded to a coarse meal, plantain flour is one of the oldest and best invalid and infant foods known. It seems to possess some power to decrease intestinal congestion; not only is it very nutritious and easily digestible but it will actually check the tropical diarrhœas safely. Dried to 8 per cent moisture in an artificial dryer, ground fine and sifted, this flour is winning a reputation in temperate as well as tropical hospitals. The peels and racms sliced, dried, and ground make a good cattle and pig feed.

There are a dozen or two distinct varieties of the true plantain, the differences lying mostly in the shape of the

fruit with its tip, size and the number and arrangement of the hands, color of peel and pulp, and the like. Whether any of the oriental Tonduks, or Tandoks, are identical with any of the Latin-American Plátanos is still undecided.

The "Congos" of tropical America, especially of Porto Rico and Panama, are a group of plantains characterized by larger bunches, more prominent bud-husks beyond the fruits, and usually smaller plumper fruits. The commonest is the Congo Verde with curved fruits in a large bunch. The Congo Morado has the young fruits of a dull purplish or maroon color, at full size becoming dark green, while the Congo Prieto has beautiful blackish-red or purple fruits; these may be identical with some of the rare and handsome colored plantains (Tonduks) of Malaya. Tonduk is the Malay for horn; hence, "Pisang Tonduk Merah" would mean the banana which has the red horn. The term Congo applied to a class of plantains might indicate that they were brought from the Congo Valley, but the West Indian slave importations were from the Guinea Coast region, around the heel of the African boot.

The Enano, or dwarf, plantain is the smallest of the species. The bunch, ripening on the plant, is a pretty sight with its glossy yellow plump fruits crowded close on a long bunch, 200 to 250 or more, a dozen times as many as the Hartón bunch contains and of very fair flavor. The plant, however, is top-heavy and may blow over unless propped up.

The Cuaranteno is a rare plantain sometimes found in back districts of Porto Rico. The leaves are extremely handsome when young; the upper surface bears numerous irregular blotches of chocolate or purple and the midrib and under side are suffused with a maroon bloom. Even the young fruits are dark mauve.

The great group of Sabás, Mafafos, Chamalucos is the only type of plantain that has ever been able to hold its own alone in tropical America when abandoned by man.

Yet the wilt disease finds it the easiest to kill and in twenty years millions of these clumps of Mafafo have gone. The whole plant is paler green than any other plantain. The fruit is short and more strongly angled. The flower-bud at the tip of the bunch is rather banana-like. The pulp is firm even when dead ripe, and it comes nearer being really sour than any other. The thick four- or five-angled peel is perhaps the heaviest of all musa peels, 20 to 40 per cent of the weight of the whole fruit. One variety, the Ceniza, is so named from the ashy-gray color of the peel while unripe. In Porto Rico there is an odd sort, the Criollo or Prieto, whose fruits are so poor that it was formerly used in making vinegar; it is the only musa now producing seeds there. Another, the Guayabo, has a much cracked and russet or reddish-brown peel; the pulp is better-flavored than the common Mafafo. A teratological freak, known as "Pata de Pato," or Duck-foot, has the fruits in each hand more or less grown together; a similar sort, the "Dominus Vobiscum" of the Philippines, has the fingers massed into blocks, hands within hands. Some of the Philippine Sabás contain seeds ⅛ inch in diameter. A variety of Mafafo or Chamaluco sent long ago to Hawaii appears to have become resistant to the wilt and is now being brought back to the West Indies as a valued return. The Mafafo bunch is rather heavy as compared with the genuine plantain, 25 to 50 pounds.

A semi-wild sub-species, *M. oleracea,* found in New Caledonia, south of the Solomons, has a long bulb or rhizome which furnishes food for the natives, who call it Poiete, and which does not fruit. A similar plant in Papua is said to be used as a root-crop, the young bulb being boiled as a vegetable and the ripe one roasted as a yam.

The African plantains have never been listed carefully. From travelers' accounts there seem to be at least three or four commonly cultivated forms through the Sudan and the countries lying to the south of it; there are a host of wild species and semi-cultivated varieties, very deserving of

study. Stanley mentioned plantains 22 inches long, and his army of "boys" were rationed mostly on cassava and plantains in their rapid marches. In East Africa there are few bananas but a flour is made from the large seeds of a wild musa.

The bananas.

Musa sapientum is hardly a species as understood today, rather an assemblage of about 150 to 200 distinct kinds of plants, nearly all of which are food-producers. Only one of the varieties has attained any great commercial prominence. The famous Gros Michel or Jamaica, or formerly Bluefields, or Guaran, surpasses most of its sister varieties in the combination of characters which make for commercial success: size and vigor of the plant; the great strength of the pedicel and its attachment to the basal part of the peel, an excellent character not possessed by several varieties of superior eating quality; the extra-good coloring-up power of the fruits, even when picked under-ripe; the ability to stand rough handling; the pulp's freedom from lumps, strings, or seeds, and its fair flavor, color and bouquet; the "build" of the bunch; its compactness and the excellent way the fingers lie in the hand so as to keep out of harm's way in transit.

This variety brings to its growers some $40,000,000 a year. The export from Jamaica to Boston began in 1869 and now comprises some 18,000,000 bunches. Gros Michel is probably only about a century old. It originated as a sport somewhere in Martinique, according to Fawcett,[1] and M. Jean François Pouyat introduced it into Jamaica some ninety years ago. There are now under test in trial plats in tropical America about six or eight more or less distinct forms of this variety, which are being tested for their comparative resistance to the wilt disease. These are not instantaneous sports but rare variants of the standard sort.

[1] Fawcett, W. "The Banana: Its Cultivation, Distribution, and Commercial Uses," 1921.

PLATE X.—Banana harvest; picking large Gros Michel bunches in Costa Rica.
Inset: the flower-bud and immature fruits.

The Monte Cristy and Johnson are giant forms producing bunches up to twenty hands or more.

The Bungulan is an excellent banana for eating out of hand. Not only is the pulp melting and luscious but the fragrance probably is not equaled by any other. It has two bad qualities, however: the peel never colors up well, only in blotches turning dull yellow; and the ripe fruits drop off from the rachis at the merest touch. The Philippine Islands and Guam may justly take pride in this very superior sort. In Cebu a form exists having the rachis bifid or even trifid.

The Rose or Date bananas are best for eating raw, at least in Latin America. There are at least two kinds, perhaps four or five. The plant is hardly of medium size; the stem is pale bright green with reddish-brown blotches and shadings toward the base. It is not a sturdy sort, yet it resists the terrible wilt. The plump straight fruits, 2 to 4 inches long, usually have reddish flecks on the ripe peel. The extreme sweetness and delicate flavor of the pulp, its thin kid-glove peel, delightful bouquet when thoroughly ripe, and dainty appearance have won for this exquisite fruit the first place among dessert bananas in the American tropics. Fried whole in oil or butter till their own sugar caramelizes brown, they are quite a delicacy. Peeled and dried whole these fruits become "banana figs," perhaps the best of all ways to eat a banana. If sliced while just underripe and dried they grind up into a rich flour, which some day will be a popular commodity. This flour contains about 4 per cent protein, a little less than 2 per cent mineral matter, about 60 per cent carbohydrates, taking the material at 11 per cent moisture. A teratological freak form has the hands all connected spirally along the rachis, the Tirabuzon, or Corkscrew banana. The Pisang Rajah of India and Malaya is a similar fruit, but the stem is stouter. Occasionally mention is made of the purple-skinned form in the Orient but it is seldom or never listed; it is called the Dátyl Morado, or Purple Date. Here, also,

belongs presumably the King of Thousands of Malaya; in 1911 a seven-foot bunch, containing some 2,000 fruits, was reported from Singapore.

The Claret, Baracoa, or Red, is a robust banana of distinct sub-species (*M. rubra*) with several forms in each hemisphere. The reddish or purplish stem in rich soil reaches a height of 20 feet or more. The midrib and petiole are dull red, the fruits dark purplish-red at first, becoming paler when ripe, even tinged with yellow. The heavy fruits are short, thick, and strongly angled, with a gummy pasty pulp when raw, becoming juicy and acid-sweet when baked. Seldom in Latin America is this variety used for human food except by the poorer classes in times of scarcity of regular staples; their market price hardly pays the cost of transportation from finca to town. It is very commonly grown on coffee plantations, partly for shade and partly for feeding to pigs and cattle. A few bunches find their way to European and North American markets; their weird color helps sell them, and many people relish them raw. There is a yellow form, practically identical except for the entire absence of the red color in stem, leaf, and fruit. It is fairly common in tropical America but attracts little attention. Freak bunches sometimes appear having some of the fruits red, some yellow, and some striped.

The Apple, or Manzana, is a very common second-class banana in Latin America. The plant is medium in size, the fruit 3 to 4 inches long, plump, cylindrical, with a thin pale yellow peel which splits if the fruit is allowed to ripen on the stem; the ripe pulp has the odor of apples and usually a sourish flavor, the texture being the most granular, perhaps, of all. The Champas of India are of this type.

The Lacatan of the Philippines is one of Blanco's original old fifty-seven varieties of native Saguings, Sabás and Tonduks, and few bananas surpass it as a fresh fruit. It is 4 or 5 inches long by 1½ in diameter with a short tip bearing the dried sepals; pulp sweet, yellowish, fragrant. It is similar to the Yellow Red.

The Latundan is one of the commonest Philippine

bananas, somewhat of the Apple type. The fruit is very pale yellow; pulp sourish, frequently inclosing one to three irregular shaped seeds as large as a small pea. It was introduced by Père Letondal from India.

The Dacca of India is a beautiful distinct type (Horan's *M. Dacca*). The fruit is 4 or 5 inches long with a thick peel and pinkish tender luscious pulp. The stem is pruinose with a waxy limey coating such as many bananas carry on the under side of their leaves. One form in Java yields an ounce of wax to every three or four leaves.

Some of the more striking varieties which had fruited in the great collection in Manila before it was broken up are:

Tampohin: a nice little banana, one of the smallest known, fruiting when only 3 feet high, so that the tip of the bunch touches the ground; fruits green when ripe.

Po-ot: another Luzon very dwarf banana; bears when 3 feet high; fruits yellow, excellent; an ideal sort for the kitchen-garden, for tubs, or to force in northern greenhouses, useful and ornamental.

Acabangtang: still another rare dwarf from Cebu Island; the fruits are whitish and very aromatic.

Pitogo, or Fig: one of the strangest bananas as to shape. The plant is normal, the bunch is of fair weight, but the fingers are shaped like figs, attached at the small end; flesh yellow, of fair flavor, peel thickish.

Pinagbilinan: the black-stem banana, of moderate height; fruit 3 inches long, yellow, with slightly bitterish pulp; the trunk with large black blotches is a striking object.

Pulticos: a wild banana (of probably undescribed species) from the Pampanga Province forests; height 6 or 8 feet; fruit 2 to 3 inches, yellow with delicious white pulp; worthy of cultivation.

Hazara: from Saharunpur, India; probably related to the Mafafos and Matabias; fruits strongly angled, square on cross-section; stem yellowish.

Calitan: another odd fruit, from Cebu Island; cross-section squarish; pulp more like the delicious Bungulan, however, than like the poor Sabá.

The twenty-two native Hawaiian varieties are for the most part connecting-link types between plantains and the bananas. Pope [1] groups them under three heads, Popoulu, Maoli and Iholena.

[1] Pope, W. T., "Banana Culture in Hawaii," Hawaii Agr. Exp. Sta. Bull. 55, 1926.

The Popoulu is probably endemic. The fruits are about 7 inches in length by one-fourth that diameter; the apex is so blunt that it is almost retuse. The pulp is firm, salmon-pink in color, and of a pleasant apple-like flavor. It is excellent raw or cooked, but is too tender-peeled for shipment.

The Kaio is a semi-wild rare banana found in the mountain gorges. The fruits are even more foreshortened than the Popoulu: 5 inches long by nearly 2½ in diameter. The pulp is like that of the Popoulu.

The Huamoa is perhaps the most nearly round-fruited banana. The large plant produces very small bunches—of only three to six fruits which are about the size and shape of a goose egg. The pinkish-yellow, sweet, firm pulp is delicious raw or cooked. The golden-yellow peel cracks badly. It was introduced into Porto Rico in 1904.

The Maiamaoli is the commonest and best cooking banana of the Honolulu markets. The long but plump-ended fruits are bright yellow with a yellow pulp of good flavor. "Maioli" indicates, perhaps, its Maori origin.

The Haikea is a large variety having a whitish bloom on all the parts. The bunch may weigh 100 pounds, and individual fruits may run to 12 to 16 ounces. The pulp is yellow, subacid to sweet.

The Hai is the largest endemic musa of the Archipelago. It resembles the Haikea but has no bloom.

The Manai Ula fruit is, like some of the Antillean sorts, reddish-brown when young. The coarse orange-colored pulp is good cooked.

The Kanalau is a medium-sized sort with very large bunches (up to 125 pounds). The waxy yellow fruits are of fine texture and excellent when cooked.

The Eleele is a giant black-stemmed musa, 20 to 25 feet tall. The young fruits appear smoked, then turn green, and finally a clear bright yellow. The orange-colored pulp is cooked. A sub-variety with purplish, instead of black, trunk-sheaths and midribs is known as the Poni.

The Aeae is a rather small sort with beautifully striped fruit and foliage. If this is a bud mutation the non-striped form should be found somewhere.

The Mahoe or Palua, is one of the best-flavored endemic musas. The fruit-stem frequently branches into two to six separate parts. Fruits are small, sweet, or subacid.

The Puhi is a rare mountain banana. The young fruits are very long and slender, the Kanaka word meaning eel-like.

The Eka closely resembles the Manai Ula, but has white instead of red flowers.

The Iho-u is a rare seldom cultivated banana. The yellow, subacid fruits are cooked.

The Iholena, or Hilahila, banana is a favorite with the Hawaiians. The thin-skinned fruits have a firm light salmon-colored pulp of subacid flavor.

The Kapua is one of the most cultivated. The fruit turns yellow long before it is ripe; it may be eaten raw, but is generally used as a plantain.

The Lele is another endemic sort preferring the damp cool mountain gorges. The nectar is secreted in a jelly-like mass inside the bowl of the petal. The angled yellow fruit tapers at each end; the ripe pulp is delicious.

Other species of Musa.

The Chinese, Governor, or Dwarf, banana (*M. Cavendishii*) is one of the best known in both hemispheres. It was found in south China and taken to Mauritius in 1826, whence it has spread over the world. The stem is thick and robust but only 5 to 7 feet tall. The leaves are comparatively broad and borne on short petioles. Except for the green peel, which never colors up well, and the susceptibility to bruising, the fruit is above the average. Since the Chinese banana is very resistant to wilt it can be set in Gros Michel fields that have been ruined. It will endure more wind without ripping than most sorts; it will also endure considerable shade, but its roots cannot stand drought and heavy soil. All through tropical America, Madeira, Azores, the Canaries, Fiji, Queensland, Florida, it is exceedingly popular. The shipping, however, is not simple; by carefully cutting off the hands and splitting them up into blocks of a few fruits each, then wrapping in paper and packing tightly in crates, they carry very well for a week or ten days in cool storage. For many years the Canary Islands have been shipping 3,000,000 bunches or more to England and the continent, eight or ten times as much as Hawaii sends over to the States. There is a giant form of this Dwarf which seems to be a kind of mutant, not very rare, both in the West Indies and in the Canaries; it is nearly double the height of the common form, otherwise the same. There is also a "Doble" or "Double" form whose stem bifurcates near the bulb; occasionally one or rarely both of these

twin stems divides again, the single bulb therefore bearing two, three or possibly four bunches. This must not be confused with the rare Gigante Enano, or Dwarf Giant, of Porto Rico, which seems to be a thick-stemmed short form of the Gros Michel.

The Robusta of Jamaica may be merely a wilt-resistant form of the common Gros Michel banana; but it is said to be a Central American variety of unknown origin.

Some of the principal species outside the three regular commercial ones are:

Musa troglodytarum, reduced by Baker to the rank of a subspecies under *M. paradisiaca,* is a very interesting wild or semi-cultivated sort, ranging wide in the jungles of India, Ceylon, and Malaya, and is in danger of extermination by wild elephants. The rachis is erect with the end bent back downward; fruits small with a yellow sweet pulp containing seeds.

Musa Fehi includes several little known forms from Polynesia. There are two distinguishing features of this species: the violet-colored sap and the erect bunch. They have been scattered throughout Polynesia and Melanesia but are absent from Malaya and the Orient. The fruits are too heavy and mawkish for eating out of hand, but roasted are greatly relished as a change from the nearly tasteless breadfruit. According to Fawcett there are still about twenty kinds of wild plantains, mostly of this species, probably, in the Society Islands; "in Tahiti alone Banks and Solander saw twenty-eight" kinds of musa. In Fiji the Soaga is an orange-fruited Fehi. The Borabora of Hawaii is a domesticated Fehi, which is supposed to have arrived in pre-Caucasian days from some of the southern archipelagoes. Some varieties have a trunk 20 feet high surmounted by the 5-foot rachis pointing skyward. Above 3,000 feet the medium-sized fruits may contain small black seeds, but in the cultivated fields below the pulp is free of them.

Musa acuminata is a controversial species common from Java to Papua. Fawcett found reason for stating there are "forty-eight distinguishable varieties, of which the most curious is the Duck Plantain, the fruit of which has a beak nearly as long as its body." The flesh is sweet; peel tight, greenish or yellowish. Celebes has a similar species, *M. tomentosa.*

The Lubang, *M. corniculata,* of Cochin-China may be absent from the Philippines now, but Blanco described it as found there. It comprises one huge fruit to the bunch.

Musa maculata of Mauritius and Bourbon is the "Figue Mignonne,"

8 feet high, cultivated for its fruits with their small beautiful spotted peel inclosing a white aromatic pulp.

The Maia Hapai, or eel plantain, of Hawaii, is of uncertain status in the genus: the long eel-like fruits grow and ripen inside the parent stem. It was described by Higgins.[1] A similar species is known as the Subang in Java.

The Maia-oa, also of Hawaii, is a wild endemic musa, probably undescribed. It seeds readily and should be used in hybridizing experiments. It may belong in the Abaka group.

None of the thirty or more varieties of abacá, *M. textilis,* bears edible fruits; the seeds and peels could be dried and ground for cattle feed.

The Abyssinian banana, *M. Ensete,* is perhaps the largest of all the genus. Both the flower-bud, before emerging from the trunk, and the seeds are eaten; the latter, some ½ to ¾ inch in diameter, are pounded up to make a coarse rich meal.

[1] Higgins, J. E., "The Banana in Hawaii," Hawaii Agr. Exp. Sta., Bull. 7, 1904.

CHAPTER XI

OTHER TROPICAL FRUITS

TROPICAL pomology holds more interest for many persons than any other branch of agriculture. A few thousand varieties of a few hundred species are known as pomological sources, but this is only a beginning. The Philippines have between 200 and 250 listed species, not mere varieties of fruits suitable for human food; there are others still awaiting discovery in the forests; and one of the very best is still known only in a small section of the undeveloped island of Palawan, although seeds of this tabu have at last been secured by the Bureau of Agriculture. The fruits of India and the Malayan region are fairly well known, and something has been done in tropical American pomology; but it will take many years to catalogue correctly the rich flora of tropical Africa. Papua is full of new fruits.

THE BREADFRUITS AND RELATED SPECIES

If a small farmer in either tropics can have only two trees, he should plant a coconut and a breadfruit; which is the more important will depend on the local conditions. Few other trees, if any, can produce so much wholesome food for man and beast. Except the coconut, few yield fruits during such a large part of the year and every year. An eight-year-old tree at Lamao Experiment Station, near Manila, bore a crop of 754 fruits, about a ton in weight or at the rate of some 50 tons an acre, or three times the yield of bananas.

Breadfruit, *Artocarpus communis* (*A. incisa*) of the Moraceæ or Fig family, is one of the most striking trees. Its

deeply incised leaves stand out strongly in the tropical landscape; they feel crisp and rough, but the younger ones are good forage for cattle, horses, and elephants; they are, in most varieties, about 12 to 18 inches long by 6 to 10 inches wide. (Plate XI.)

The classification of the 50 to 100 varieties is difficult. The large green or yellowish fruits are usually roundish and from 4 to 8 inches in diameter. They vary from completely seedless forms to those having little pulp and many large seeds. Some may be eaten fresh, but most sorts must be cooked even when fully ripe. The pericarp may be nearly smooth or covered with short soft spiny protuberances; it is thin and filled, as is the entire tree, with a very sticky latex. The pulp is of a peculiar structure; the fibrous core, about 1 inch in diameter, extends from the peduncle to the center of the fruit. Between the core and the pericarp the white or yellowish, flaky, spongy pulp extends, coarser and nearly fibrous next to the core and denser toward the rind; the seeds, or abortive ovules, if any, are near the core.

Baked, roasted, boiled, or better parboiled and then fried in thin slices, this bread-like pulp is very wholesome. Unless allowed to ripen fully on the tree and then kept a few days till mellow, there is not much flavor or odor in breadfruit pulp. Part of the starch in the firm slightly under-ripe pulp changes to sugar when the fruit becomes mellow; then there is a peculiar aromatic sweetish or slightly bitter flavor. The fruit does not rot like other sorts, but melts. In some parts of Polynesia the aborigines press the raw or sometimes partly cooked fruits into pits in the ground, which are then covered over; the pulp undergoes a slow fermentation and may be kept in the pit for several months, then cooked.

Breadfruit pulp is perhaps the easiest to dry; quarter-inch slices may be dried enough for grinding to a fine flour in a copra dryer or similar oven in three or four hours. The flour is nearly pure starch: 56.9 to 75 per cent carbohydrates, 3.3 to 6.1 per cent protein, 1.3 to 1.6 per cent ether

extract, on the regular 10 per cent moisture basis. A four-pound fruit, sliced whole, gives about 2 pounds of a cheap but nutritious flour for cattle feed. At 2 cents a fruit, allowing ½ cent a pound for manufacturing, the feed costs 1½ cents a pound. It keeps very well and enough has been made at the By-Products Plant of the Porto Rican Department of Agriculture and Labor to prove its suitability and wholesomeness.

By paring and coring the fruits and thoroughly drying the slices, a nutritious flour for the table may be obtained. The dried or slightly toasted slices, whole, as chips, or broken in small pieces are delicious eaten hot with butter or cream or in milk, and will some day be very popular.

The huge catkins of the male inflorescence, yellowish, 1 to 2 inches in diameter by 4 to 8 inches in length, are boiled in sirup and eaten as a dessert.

The leaves are very easily dried. Ground to a coarse meal, they form an excellent feed for animals, being surprisingly rich in protein, one analysis showing about 24 per cent.

Usually one large and one light crop of fruits are borne every year. The time may vary considerably and there may be an almost continuous crop from some trees.

In tropical America there is a so-called "seed" breadfruit of very uncertain identity. The leaf is cut in only half as deeply as the seedless sort. The fruit is full of seeds about the size of a chestnut, and the rind is covered with cone-shaped soft spines. It is very distinct from the seedless, but Britton and Wilson [1] regard it as botanically identical. In Greytown, Nicaragua, the author found a very large tree bearing fruits and leaves which combined the characters of both these trees. This seed breadfruit is said to have been brought to the West Indies from French Polynesia by a French boat which was captured by the English some time before Captain Bligh succeeded in introducing the seedless form from Tahiti in 1793.

[1] Britton, N. L. and Wilson, P., "Scientific Survey of Porto Rico and the Virgin Islands," Vol. V, Pt. 2, 1924.

Breadfruit seeds, dried and ground, are excellent feed for live-stock. The analysis shows (at 10 per cent moisture) up to 14 per cent protein, 6.6 per cent ether extract, 63.8 carbohydrates, and only 2.8 per cent fiber.

The marang, *Artocarpus odoratissima,* of the island of Mindanao, is one of the finest of fruits for eating out of hand. The tree resembles the breadfruits, but the leaves are either entire or lobed. The brownish fruit is 5 to 10 inches in diameter and covered with soft spine-like processes. The very fragrant snow-white pulp is very juicy, acid-sweet, aromatic, and melting; the seeds are embedded in globular masses of the pulp, and may be roasted and eaten like peanuts.

The buah-perian or mandalika, *A. rigida,* is a common Malayan fruit. The tree is medium-sized, with small oval leaves. The fruit is covered with sharp spines and turns yellow when ripe. The sack of orange-yellow pulp surrounding the round seeds is juicy and sweet.

The wild breadfruit, *A. nobilis,* resembles the seed breadfruit of Tahiti and tropical America, but the leaves are not cut and the fruit is cone-shaped or cylindrical.

The lemasa, *Artocarpus Champeden,* is a small tree, native of tropical Asia, resembling the jak, but very superior thereto. It is now growing in Porto Rico.

The gomihan, *A. elastica,* is another little-known Philippine fruit. The tree resembles the breadfruit. The fruit is 4 inches in diameter, orange-yellow, and covered with long, coarse, thread-like hairs. The whitish pulp is sweet, juicy, and aromatic. The seeds are eaten, roasted.

The kledang, *A. lancœfolia,* is a small tree, native of Malaysia. The fruits are edible.

The mitnai of Cochin-China is apparently a species of Artocarpus, probably not described. This robust rapid-growing tree has been introduced into the Philippines.

The jaks, *A. integrifolia,* are such large and interesting fruits and the trees so well-behaved that it is difficult to explain the general lack of knowledge concerning them. There are numerous varieties through India, Ceylon, and Malaysia, but no one seems ever to have listed them. In Ceylon, according to Macmillan,[1] the two principal types are known as Waraka and Vela, the former with a firm rind,

[1] Macmillan, H. F., "Tropical Gardening and Planting," Colombo, 1925.

like a watermelon, when ripe, the latter with a soft pericarp. The Peni-waraka, or honey jak, has a sweet pulp; the Kuru-waraka has small roundish fruits. There are hundreds of Vela jaks scattered throughout the West Indies, and some of the fruits may reach 50 pounds. In the Middle East, however, specimens sometimes weigh up to a hundred-weight "or more." Since a 50-pound fruit contains about 30 pounds of acid-sweet (15 to 22 per cent sugar), aromatic strong-smelling pulp and some 10 pounds of seeds, the jak is a very important food and the largest tree-fruit in the world. Since the native name is Jaka, the common misspelling, jack, is incorrect. The pulp from individual trees varies in flavor considerably. The seeds, boiled or roasted, are very nutritious and usually not bitter; the carbohydrates comprise 23.5 and the proteids 5.4 per cent, with only 1.6 per cent fiber.

There are at least thirty-five other species of Artocarpus, most of which bear edible fruits.

To the Fig family also belongs *Treculia africana,* the owka of West Africa. The huge fruit weighs 20 to 30 pounds or more, and its seeds are made into an edible meal. Both the cream-like sap and the fruit of *Sahagunia strepitans* of Brazil are esteemed by the aborigines.

THE PAPAYAS

The papaya, *Carica Papaya,* is an important food and drug fruit in Ceylon and the West Indies. This soft-stemmed tree belongs to the small family Caricaceæ; the passifloras are very close relatives. The many forms and varieties vary from 6 to 30 feet in height. Some varieties normally branch but most have a straight tapering stem, with a crown of large palmately lobed leaves. The roundish, obovoid, or cylindrical fruits are borne on very short peduncles just below the leaves.

Most varieties are diœcious.[1] A hermaphrodite[2] variety

[1] Staminate and pistillate flowers on different plants.
[2] Both sexes in the same flowers.

was bred at the Lamao Experiment Station, wherein has been for many years the largest collection of tropical fruits, of the Philippine Bureau of Agriculture; by the sixth generation there were few unisexual plants and by the eighth there were practically none. Cutting back a male plant sometimes changes the sex.

The fruit has very thin dark green cuticle, changing to yellow or orange when ripe. The pulp is pale yellowish-orange in the poorer sorts, and the dark reddish-orange of the better kinds may be nearly tasteless or almost too sweet and spicy. Even when immature the fruit contains no starch. The fruit may weigh from 1 to 25 pounds, according to variety (or sub-species).

There is no better breakfast fruit. If consumed in great quantity the papain-content might cause in man, as it does in canaries, a softening and even bleeding of the dermal tissues. The unripe fruit makes an excellent dessert preserve if cooked in sirup with spice. The seeds are peppery.

The immature fruits when scratched exude a thin whitish latex which coagulates soon on exposure to the air. Depending on the size of the fruit, from 5 to 10 or more ounces of dried latex may be obtained for each tree a year. The thin pericarp should be lightly cut or scratched with a bamboo splinter or a piece of glass, early in the morning, and the latex caught in a suspended glass or porcelain cup or on banana leaves. Spread out, preferably in the shade, where the wind can reach it, the gum should be nearly dry in one day; low artificial heat may be necessary in cloudy weather. The gum, powdered, flaked, or "riced," must be kept in air-tight containers. It is used in chewing-gum manufacture and in medicine the standardized extract, papain, is a valuable vegetable pepsin. The fresh latex, even, will digest the skin of the fingers, especially under rings, in a few minutes. Each fruit may be tapped three to six days a week as long as it yields latex. Tapping should continue throughout the year. The plant lives from two to five years. Ceylon is the heaviest producer by far. For many years Mont-

serrat in the Lesser Antilles has turned out a good grade of gum in large amounts; the drying plants have been paying around 35 cents a pound for the "milk" brought in by small farmers; about 4½ pounds of latex yields 1 pound of gum, worth from $1.00 to $4.00 a pound. The United States is the heaviest consumer, importing some $80,000 worth annually.

The largest papaya plants, a foot in diameter and branched, are found in Liberia. The largest fruits, perhaps, are those of a variety grown in Guam. Both this and the sister species, *C. cundamarcensis,* the mountain papaya, are natives of tropical America; the latter, common in Colombia, bears small sour fruits suitable for preserves. Some twenty-one species have been described in the American genus Carica, but they are confused.

THE DURIAN

The durians, *Durio zibethinus,* are a famous group; the family is the Bombacaceæ. The common varieties extend from Burma down through the Malay Peninsula, presumably their original habitat, into the East Indies and Mindanao. Very distinct types or, quite possibly, different species occur in Borneo; some of these have no bad odor, and are much smaller than the ordinary durian; some have yellow, or even orange, pulp.

The tree is rather large, 40 to 80 feet. The under surface of the leaf is covered with a fine close satiny coat of shining golden hairs. The fruit weighs from 4 to 8 pounds or more, and is covered with sharp conical spines, so that it cannot be held on the open hand in safety. As Macmillan expresses it, the fruit "possesses when mature a very offensive odor, more especially so on first acquaintance." The effluvium of the fresh pulp resembles garlic, Limburger cheese, and some spicy sort of resin; after eating a bit of the pulp the odor is scarcely noticed by the eater. The flavor of the creamy-white or yellowish custard-like pulp is triplex in effect: first a strong aromatic taste, followed by a delicious sweet flavor,

then a strange resinous or balsam-like taste of exquisite but persistent savor. "The chemical body which is responsible for the very pronounced odor is probably one of the sulfur compounds with some base perhaps related to that in butyric acid; it is not an oil nor a sugar, not a true starch nor an inulin, but according to Dr. W. E. Pratt it is a substance new to the organic chemist. The pulp contains a compound which, it is believed, is related to erythrodextrin, but seems to exist, if such, in a new form in this fruit." [1]

In the Malayan countries the durian is more popular than the mangosteen. It is currently believed to possess rejuvenating properties. Only a few trees exist in the western hemisphere. It should become extremely popular, once the prejudice against its odor disappears.

THE MANGOSTEEN AND RELATED SPECIES

The world's best-flavored fruit is generally conceded to be the mangosteen, *Garcinia Mangostana*. This is only one of an outstanding group of fruit-trees of Asia and Africa; there are over 200 species of Garcinia, fully one-third of which bear edible fruits, many of which are not yet sufficiently known. The family is the Guttiferæ.

The trees with their dark green shining leaves and stiff branches stand 15 to 30 feet high. The growth is very slow; no fruit should be expected before the tenth year. Two crops a year are borne for many years.

The oblate-globose fruits are dark purplish, 2 to 3 inches in diameter, and bear the two large and two small leathery sepals adherent to the base. The pericarp is fleshy and half an inch thick; it contains a white latex superficially and a purplish juice within. The pulp is snow-white with crimson veins; the texture is melting, very little fiber and exquisite juice. In the five or six sections there is usually one viable and one or two aborted seeds. These sections may be squeezed out or scooped out with a spoon. The pulp contains 16.8 per cent sugar.

[1] Barrett, O. W., Philippine Journ. of Science, Nov. 1912.

Strange to say, there seems to be no variation in mangosteen fruits, whether grown in Cambodia, Java, or Trinidad. There are only a few thousand trees in the New World; Dominica has the greatest number, Trinidad the next; two trees [1] have been giving two crops a year, a better performance than obtains in Singapore orchards, in Porto Rico for many years. An effort is being made by a large concern in Honduras to produce these fruits on a large scale for shipment to the northern markets at fancy prices.

While the species does not vary, the genus does. No less than 210 species of Garcinia have been described; mostly Malaysian, but Africa has a good number. The United States Department of Agriculture has spent a large amount of time and money not only to introduce the mangosteen but also a considerable number of its sister species into tropical America and Hawaii.

The matau or gamboge tree, *Garcinia tinctoria,* of south India and Malaya promises to become popular in tropical America. The peach-shaped fruit is bright yellow, 2 to 3 inches in diameter and very thin-skinned. The flavor of the yellow melting pulp is between that of a good strawberry and a sour apple; with sugar and cream it is an excellent breakfast fruit. The tree attains 40 feet and is a sure and heavy cropper. The fruit does not decay quickly. It has already begun to vary in Porto Rico.

The baniti, *Garcinia dulcis,* is very similar to the matau. It is native to the Philippines, Burma, and Malaya. It is cultivated in Java. Subacid forms are known, but usually the fruits are very sour.

The bruas, or mangis hutan, *G. Hombroniana,* of the Malay Peninsula and Nicobar Islands, is closely related to the mangosteen. The tree is larger but the fruit only 2 inches in diameter, and redder than the superior sister species. The white juicy pulp has the flavor of the peach. It is cultivated.

The kokam, or katambi, *G. indica,* a native of western India, is cultivated around Bombay and in Mauritius. It has been fruiting in the West Indies for some thirty years. The fruit resembles a small mangosteen as to color and shape, but the pulp is sour and deep purple. "Kokam butter" is made from the oily seeds.

[1] Introduced from Trinidad by the author in 1903.

PLATE XI.—*Above:* left, tamarind (*Tamarindus indica*); right, seedless breadfruit (*Artocarpus incisa*). *Below:* the most primitive habitation, a Mangayan home in a Philippine jungle.

The kariis, *G. laterifolia,* is indigenous to the Philippines and Java, where it is called djawura. The roundish or mandarin-shaped fruit is 1 to 1½ inches in diameter. Sweet forms occur in Java, sour in the Philippines.

The tromeng, *G. Oliveri,* of Indo-China has oblong reddish fruits about 2 inches long, very acid but popular. The pulp is sliced and preserved with salt.

The kadis, *G. Barrettiana,* is endemic in the great Cotabato Valley of Mindanao where it forms a tree 15 to 20 feet high. The fruit is of an unusual color, light orange, mandarin-shaped, and 2 to 2½ inches in diameter. The pulp is orange, juicy, subacid, and of good flavor; the fleshy pericarp also is edible. This is one of the most promising of the new garcinias.

The bunag, *G. Mooreana,* is another recently discovered garcinia, endemic in Jolo and Palawan islands in the Philippines. The fruit is much like the mangosteen but a little smaller and sour-fleshed. The flavor is very agreeable.

The roi, *G. Benthami,* of Indo-China, is a large tree, bearing fruits about 2 inches long, smooth, and obpyriform. The pulp is white, acid, and of agreeable flavor.

The hila, goraka, or aradal, *G. Cambogia,* of Ceylon and western India, is a small tree with drooping branches, like the binucao. The fruit is yellowish or reddish, about the size of an orange, with six or eight deep longitudinal grooves in the fleshy pericarp. The pulp is acid but pleasant. The Singalese dry it and use it in curries.

The kirasa, *G. celebica,* indigenous to the Malay Archipelago, is closely related to the mangosteen. The white fleshy pulp is acid.

The hussur, *G. cornea,* has long been known from Malaya and has now been reported from Burma. The dark purple fruit is roundish and about 1½ inches in diameter; the pulp is subacid, white, and pleasantly flavored.

The cowa, *G. Cowa,* is a large handsome tree, 40 to 50 feet high, of Burma and Assam. The fruit resembles the hila, yellowish, deeply grooved, orange size, and with a mammillate apex. Both pulp and pericarp are well-flavored.

One of the most promising of the oriental garcinias is the Asam gelugur, *G. atroviridis,* a cultivated and wild tree, 30 to 50 feet, indigenous to the Malay Peninsula. The orange-yellow roundish fruit is some 3 inches or more in diameter; the pericarp is fleshy, firm, and acid; the pulp is translucent and very sour for eating fresh, but excellent stewed with sugar, according to H. N. Ridley.

The kelabang, *G. bancana,* is a large tree of the wet swampy jungles of Banka, Sumatra, and the Malay Peninsula. The ovoid fruit is green and fleshy and relished by the natives.

The binukao, *G. Binucao,* is indigenous to the Philippines. The

tree has long, straggling drooping branches and very abundant fruits of various sizes closely attached to the short branchlets. The mandarin-shaped fruits are greenish-yellow, 1 to 2 inches in diameter. The pulp is very acid. It fruits heavily in Porto Rico.

An Indo-Chinese species, *Garcinia cochinensis,* has subglobose fruits 2 inches across, reddish-yellow, fleshy, and pleasantly acid. Another, *G. costata,* is a tall tree in the mountain forests of Perak Province in the Malay Peninsula. Its fruits are tomato-shaped, 2 by 3 inches, with many longitudinal grooves, pale rose to red.

The malabu, *G. Cumingiana,* of northern Luzon is, according to P. J. Wester, a medium-sized tree which should be tested as a stock for the mangosteen. The fruit is roundish, 2 inches in diameter, fleshy, acid, and edible.

The tjeuri, *G. dioica,* of Java, is a first-class fruit-tree. The fruit resembles a small mandarin in size and shape; it is pale yellow and has a refreshing flavor.

The trameng, *G. Delpyana,* is a tall tree indigenous in Indo-China. The globose, smooth, yellowish fruit, about 1½ inches in diameter, has a spongy pericarp and a pleasant-tasting pulp.

The pildis, *G. dives,* is a widely distributed Philippine tree with roundish fleshy edible fruits, nearly an inch in diameter.

The kandis, *G. globulosa,* of the Straits Settlements, is one of the best of the garcinias found by Ridley in that rich region. This forest tree attains 50 or 60 feet. The fruit is berry-like, orange-colored, round, pulpy, and of a pleasant flavor. It is abundantly productive. Another species, *G. parvifolia,* of that region, has the same name and similar acid fruits.

Another large forest tree of the Malay Peninsula and Sumatra, the kandis gajah, or sibangor, *G. Griffithii,* has very large shining leaves and bears large mandarin-shaped fruits, 2 by 3 inches, greenish-yellow, juicy, and acid.

Wester[1] reports still other garcinias from the partly explored Indo-China region, as follows:

G. Harmandii, the remir, is a tree of compact growth. The fruits are purplish, nearly an inch across, with sweet pulp of pleasing flavor.

G. fusca, the bua lueur, is a small tree with ovoid or roundish, pointed, smooth, fleshy fruits with a good but acid taste.

G. Loureiri, the buanha, is a good-sized tree which is occasionally cultivated. The fruit is short-oblong, 2 inches long, and grooved. The pericarp is yellow without and reddish within, an unusual color

[1] Wester, P. J., "Edible Garcinias and Possible Mangosteen Stocks," Journ. of Agr., Porto Rico Dept. Agr. and Labor, Vol. X, Nov. 3, 1927.

arrangement. The pulp is white, acid, and agreeable. The natives dry the sliced pericarp and salt it; cooked with rice it gives a fine flavor.

G. merguensis, the sonve, is a handsome tree which bears roundish fleshy fruits the size of a large grape. This species runs over into Burma and down into the great Peninsula.

G. Planchoni is a large tree of the steamy jungles. The fruit is orange-like, about 3 inches in diameter, greenish-yellow, grooved and covered with wart-like protuberances. The thick pericarp is fleshy, acid, and, like the pulp, of an agreeable flavor. The natives dry the fruit in slices for consumption during the off season. Pierre, the authority on Indo-Chinese trees, states that this species merits cultivation.

Other oriental garcinias of promise are:

The cherapu, *G. Prainiana,* is a small tree resembling the mangosteen. The 2-inch roundish fruit is smooth, yellow, and has an acid edible pericarp and a subacid pulp. According to Ridley the cherapu is eaten like the mangosteen. It is native to the great Peninsula.

The tikul, *G. pedunculata,* is a rapid-growing 60-foot tree of Bengal and Sylhet. This is one of the largest-fruited species of the genus, the orange-like fruit measuring sometimes more than 4 inches in diameter. The yellow pericarp is very acid, but, like the pulp, of pleasant flavor. The natives use the fruit in many ways: dried in curries, and as an "ade" fruit. It is cultivated.

The bubi-kowa, *G. paniculata,* is a forest tree of the Bengal and eastern Himalayan mountains. The fruit is round, yellow, like a large cherry; the high-flavored pulp reminds one of the mangosteen.

The selapan, *G. macrophylla,* of Sumatra has a pomiform acid fruit relished by the natives.

The kirindur, *G. lanceæfolia,* of Assam and Burma, bears plum-like orange-yellow fruits which are "much esteemed by the native inhabitants."

Australia has a meritorious member of the genus, *G. Mestooni.* The roundish fruit, 2 by 3 inches, is smooth, green, fleshy, and of a pleasantly acid flavor.

Besides those already mentioned, several other Philippine garcinias are entering cultivation. Most of the thirty known species there are not yet studied pomologically.

The kamani, *G. rubra,* occurs in the southern part of the Archipelago. The yellow to red subrotund fruits are over an inch in diameter, and, according to Wester, "fleshy, acid, and edible."

The tamil, *G. tetrandra,* occurs with the preceding species. Its fruits are larger and quite sour and of a flattened shape.

The kabangla, *G. mindanensis,* is a small slender tree of 30 feet. The fruits are acid, but quite edible, about 1½ inches across. The flowers are red.

The danealan, *G. subelliptica,* is a 30- to 40-foot tree of the eastern coast of Luzon. The yellow flattened fruits, 2 inches across, are fleshy and acid.

The katuri, *G. venulosa,* is endemic to the Philippines. The 2-inch fruit is smooth, greenish, and has an appetizing pulp.

The kanubi, *G. Vidalii,* occurs throughout the Archipelago. The fruit looks like the mangosteen but has fleshy acid pericarp yellowish instead of purple, and the pulp is sour instead of deliciously sweet; the seeds are ten or more, but cultivation would probably alleviate that factor.

Continental Africa has several very interesting garcinias out of the eighty which have been described to date; and already sixteen species have been listed from the dark jungles of Madagascar.

The pama, or imbe, *Garcinia Livingstonei,* is a coarse-branched tree, 15 to 30 feet high, fairly common along the low veld of Portuguese East Africa. The fruits are reddish-purple, covered with a blue bloom, like the old-fashioned blue plums. The shape of the fruit is oblong, about 2 to 2½ inches long by half that diameter. The fleshy pericarp and the highly colored pulp are used by the M'chopes, Bitangas, and other tribes of that region in preparing a purplish claret-like wine. The imbe has fruited in southern Florida, but probably it is too exacting in its ecological requirements for general cultivation.

The ntu, *Garcinia Conruana,* is a native of the Cameroons. This giant species attains a height of 90 feet or more. The roundish fruit, 1½ inches in diameter, is reddish-yellow, with orange-colored pulp. The seeds also are edible.

The umbindi, *G. Gerrardi,* is a large shrub, native of Natal and Zululand. The black ovoid fruit is nearly an inch long; the colored pulp has only one seed.

The mdogolo, *G. Wentzeliana,* is almost the only garcinia which is a woody climber. This vine of tropical Africa has sweet juicy fruits, like small grapes, and of agreeable flavor.

Among the many species of Garcinia which have been introduced by the United States Department of Agriculture in the attempt to find a suitable stock for the mangosteen, one from Hongkong, *G. oblongifolia,* has borne fruits whose flavor suggests the mangosteen.

The mamey, *Mammea americana,* is native to the West Indies and northern South America, and is a close relative of the garcinias. It has spread fairly well to Mexico and to southern Brazil; but, though introduced over a century ago, it has never succeeded in the tropics of the Old World. It is a striking tree, 40 to 60 feet high, with a dense head of stout branches which are always full of the very darkest green shining thick leaves 4 to 5 inches long.

The fruit is from 4 to 8 or even 10 inches in diameter, roundish or flattened, but tapering slightly toward the tip; no two fruits are quite the same size or shape. The leathery rind of the mamey is grayish or yellowish-brown and bark-like. The pulp is always firm but not really fibrous; orange, or in some forms yellowish or reddish; tough but edible till fully ripe; the fruits vary greatly in time of ripening, from a few to many months, thus keeping up an almost continuous crop. The seed, one (or occasionally, in large fruits, two or three), is large, irregular-shaped, and rough; the pulp may or may not adhere closely.

There are, contrary to common belief, three or four varieties of mamey; one is quite juicy, one dry; some trees bear sour-pulp apricot-flavored fruits; others sweet; some mawkish, some spicy. Few persons accustomed to good fruits relish it raw. Cooked with plenty of sugar and spice it is very decidedly improved. The jam is good, if lime juice or some other fruit, like the iba (Cicca) be added. Mamey paste is a staple dulce throughout Latin America, cheaper than and inferior to the "pasta de guayaba." Mamey pulp, as a filler for higher-grade fruit pastes and butters, has a good value. It deserves wide cultivation in the Orient. The word Mammea was modeled on the Antillean Arawak name *mamei.* Mamee-apple and Santo Domingan apricot are West Indian synonyms.

Two or three species of Rheedia, related to Garcinia, are native to tropical America.

The madroño, *Rheedia Madruno,* is a lemon-shaped fruit cultivated in Colombia and neighboring countries. The pulp is whitish, juicy, sub-acid, and aromatic.

The berba, *R. edulis,* of Central America has yellowish sub-acid flesh; the fruit is grape-like, borne in clusters.

The cupí, *R. Cupi,* of the Orinoco Valley is another fruit-tree requiring study.

The bakuparí, *R. brasiliensis,* is indigenous in southeastern Brazil, a handsome tree according to Popenoe.[1] The fruit resembles a large lime, orange-yellow; the pulp is snow-white, translucent, in flavor resembling the mangosteen. It is well worthy of extended cultivation.

Another species, *R. macrophylla,* the bacury-pary, is cultivated about Pará. The acid fruits resemble those of the bakuri, *Platonia insignis,* a large forest tree of northern Brazil. The orange-like fruit has a pleasantly acidulous white pulp. It is entering domestication and already can be bought in tins.

THE MANGO AND RELATED SPECIES

The 500 or so named varieties of mango, of some six species, furnish many hundred thousand tons of nutritious fruit pulp to about one-fifth of the earth's inhabitants. Not only the home habitat, southern Asia, but also entire tropical America, Polynesia, and the coastal regions of tropical Africa have millions of these exceedingly vigorous old fruit-trees.

One of the earliest pieces of Sanskrit literature records the fact that a certain Rajah, being delighted with the mangos of a certain locality, commanded that all the highways and byways of his realm should be planted with his favorite fruit.

The mango, *Mangifera indica,* of the Anacardiaceæ or Cashew family has been under cultivation for 5,000 or 6,000 years at least. It is probably a cultigen now; similar species, however, occur apparently uncultivated in Malaysia.

The seeds of mango are peculiar. There are not only the monoembryonic type, which does not come true to seed in most cases, and the polyembryonic, which should come true, but also some forms which appear to conform to neither of these types.

[1] Popenoe, Wilson, "Manual of Tropical and Subtropical Fruits," 1920.

The mango tree is propagated in the Philippines from seeds, since all the indigenous varieties reproduce thus with no apparent variation. In India inarching, marcottage, layering, and recently grafting are the methods employed. Formerly in the American countries patch-budding was supposed to be the best method of graftage, but recently it has been learned that terminal sprigs 2 or 3 inches long, if cut just when they start to flush and inserted in a flushing branch, will start growth immediately. Unfortunately fungous enemies frequently attack the young growth, sometimes killing the cion shoot before it can develop resistance. (Plate XII.)

The tree reaches a height of 70 feet and may have a 5-foot bole. It grows very rapidly and endures any amount of pruning, and therefore is widely used for firewood and charcoal.

The mango fruit varies from tomato-shape, like the Itamaracá of supposedly Brazilian origin, to long oblong sorts like the Sandersha, 10 inches long. The size varies from little plum-like forms to the huge Kumrajali which is said to attain the weight of 5½ pounds ("2700 grams"), probably the heaviest single-seeded dicotyledonous fruit in the world. The pulp may be bland and fiberless like the famous Carabao of the Philippines or the strongly resinous turpentiney flesh may be so stringy as not to be worth eating. The pericarp varies from dull green or russet-brown to bright yellow, red, purple, and even bluish. The color of the pulp also varies from pale yellow or whitish to dark orange-red. The sugar-content runs from below 12 to over 19 per cent. The seed kernel is edible when cooked.

Probably 99 per cent of the fruits are eaten fresh. Some are made into spiced pickles, chutney, particularly, being very popular, Some are cooked before ripening. In some regions the thick juice of the very ripe pulp is dried in the sun (or oven) in the form of slabs and chips. Some are canned. The unripe fruit contains pectin, hence goes well

in jams and preserves. The pulp contains gallic acid and a peculiar substance which often causes trouble in the canned fruit by changing the color, odor, and to a less degree the taste.

Besides the several types of mango in Malaysia there is a strange set in the West Indies, which seems to have no close relatives in the Orient, very strong-flavored, spicy, and of odd shapes. The mango did not reach America very early; Porto Rico received it not earlier than 1740; yet the number of American varieties is already large. It was introduced into the Philippines in the sixteenth century.

The mango is remarkably free from insect pests. A fruit-fly attacks some varieties in tropical America and this may, through quarantine regulations, prevent export to the northern markets. There is also a seed-weevil.

To some individuals the juice which oozes from the severed peduncle is quite poisonous, not, as sometimes believed, the fruit itself.

Although the mango sometimes fails to set a good crop of fruit, on account of rains or strong winds at the time of flowering, or through fungous (anthracnose) attacks, it is one of the surest croppers. The mango may some day become known as a forage plant: the leaves are eaten by cattle; the unripe fruits (before the starch turns to sugar), sliced and dried, stored as chips or ground, are an excellent feed; the fodder and feed yield from an acre of cultivated mangos must be comparable to that from an acre of bread-fruit. Probably no other tropical fruit could serve as the sole article of diet so long as the mango; in some regions the inhabitants eat practically no other food for weeks.

The bauno, *Mangifera cœsia,* resembles the mango as to habit. It is indigenous in the Philippines and most Malayan countries. The large green fruit contains a very aromatic white pulp, eaten either out of hand or preserved. Several forms are known. The seed is huskless.

The paho or pahutan, *M. altissima,* is another native Philippine fruit like the mango. The green or yellowish fruits are pickled.

The huani, *M. odorata,* of the southern part of the Philippines

has large mango-like fruits with yellow flesh of strong resinous flavor. It will fruit in regions too wet for the mangos.

The bachang, *M. fœtida,* resembles the bauno and huani in bearing large aromatic fruits resembling the oblong mangos. It is native of Malaysia.

The kuwini or bumbum, *M. odorata,* occurs wild in the Malacca district and is cultivated in Java. The oblong fruit is "yellowish green, the flesh yellow, sweet, with no turpentine flavor."

The manga monjet, *M. laurina,* is a wild and cultivated tree of the Malay Archipelago. The small elliptic-oblique fruit is the size of a plum, and occurs in numerous varieties.

The binjai, probably *M. verticillata,* is both wild and cultivated in Java, Sumatra, and the Malacca district. The strongly flavored fruit is reddish-white, oblong-obovate in shape.

Two other species, *M. zeylanica,* of Ceylon and *M. sylvatica* of Nepal and northeastern India, are of uncertain position and value; they may later be reduced to subspecies of *M. indica.*

From Mexico to Brazil, one of the commonest fruit-trees is the jobo, yellow mombin, cajá, or hog-plum, *Spondias Mombin* (*S. lutea*). For centuries this old American indigen has furnished incalculable quantities of food to the aborigines. In the open or in the virgin forest it always bears heavily. The yellow plum-like fruit is about 1 to 1½ inches long; the very juicy pulp is sweetish or sub-acid and has a turpentine tang in most trees. Popenoe speaks of "many varieties." The individual fruits on a tree vary as much, perhaps, as those from trees in different countries. The tree reaches 60 feet in height. In Mexico a wine is made from the ripe fruits.

The Spanish-plum, ciruelo, or red mombin, *Spondias purpurea,* is very superior to the yellow mombin, but is much more common in Mexico and Central America than elsewhere. It is cultivated widely. The fruits are of various shades from yellow to dark brownish-red, and are from 1 to 2 inches in length, plum-shaped. There are several varieties or sub-species, the greatest range occurring in Mexico. The spondias are very easily propagated from large stake cuttings.

The vi, or ambarella, *Spondias cytherea,* is a coarse-

branched tree of the South Pacific islands. The oblong yellow fruit is the largest of the genus, 2 to 3 inches long. The pulp is acid or sweetish, yellow to brownish, very strong flavored in most sorts, and of pronounced odor like over-ripe pineapples. There are several varieties. It is not common in tropical America and is the most difficult of the genus to propagate. The spiny large seed is objectionable.

S. pinnata of the Philippines resembles a large ciruela. It is rare in cultivation.

The imbu, *S. tuberosa,* of Brazil, is probably the best of the genus as a fruit-producer. The plum-like yellow fruit is very abundant and popular. A jelly and an "imbuzada" dessert, the greenish juice with milk, are made from it. The swollen roots may be used for food in times of scarcity.

The dao, *Dracontomelon Dao,* of the Philippines, is a related tree of 100 feet or more. The fruit resembles the ciruela. The lamio, *D. edule,* is a similar tree with larger fruits.

The kundangan, *Bouea macrophylla,* is a Malayan tree bearing plum-like fruits, subacid, of good flavor, about egg-size.

The kamiring, *Semecarpus cuneiformis,* is a Philippine shrub or small tree. The red fruit is like the cashew. The manalu, *S. gigantifolia,* bears purplish fruits in large clusters on the trunk.

One of the best nuts is produced by the cheronjee or lonefo, *Buchanania latifolia,* indigenous from India to Burma, also one of the Cashew family. The pear-shaped kernels have a delicate nutty flavor and are eaten raw or made up like almonds into sweetmeats; they also yield a wholesome oil.

The cashew-nut, *Anacardium occidentale,* is mentioned in Chapter XVI.

THE AVOCADOS (PLATE XIII)

After the coconut, the banana group, the mangos, and the breadfruits in importance in the tropics, comes the avocado tribe. These Lauraceæ are American trees of great importance as human food-producers. There are between 400 and 500 named varieties belonging to some five species. The avocado group consists of: *Persea americana,* the avocado of the West Indies and Guatemala; var. *drymifolia* (*P. drymifolia*), the Mexican avocado; hybrids between these two species; the rare but extremely valuable coyo, *P. Schiedeana,* of Guatemala; the peculiar beaked type of cen-

tral Venezuela; the yás, probably *P. Pittieri,* of Costa Rica; and a few unclassified types of Peru, Colombia, and other districts of Central America and the Antilles. Some of the cultivated avocados (at least in the United States) belong to *Persea leiogyna,* native probably in tropical America.

The old Aztec name was ahuacatl; the Spaniards modified it in aguacate, and for a few years it looked as if the name "alligator pear" was going to cling to this fruit even in northern markets. Avocado is frankly a made-up name, and even this is often mispronounced with one or both a's long. The Quekchi name for the Guatemalan type is *O* or *Oj;* the Mayas call it *On.*

Whether the palta of ancient Peru was domesticated before the ahuacatl of the Land of the Aztecs is debatable.[1] The cultivated species are apparently cultigens, but a wild species, which might have been the origin of the tame ones, was recently discovered in the mountains of Porto Rico, *Persea portoricencis.*

The avocados are medium-sized trees of open-branch habit. The Guatemalan and Mexican types do best at elevations above 1,500 feet; the West Indians are not particular, attaining 60 feet in either clay or sand, low or high elevations.

The strange sex-reversal of avocado inflorescence has been studied of late; it appears that, at least in most varieties, the one-day flower matures either the staminate or pistillate organs in the forenoon and then, after a period of rest, so to speak, in the middle of the day, the complementary set of organs comes into play: thus one tree may display only apparently female flowers in the morning, viable for the pollen from a tree whose flowers at that moment seem to be male, and in the afternoon the tables may be turned.

[1] See discussion by Popenoe in "Manual of Tropical and Subtropical Fruits," 1920; also "Avocado Culture in California," Bull. 365, Calif. Agr. Exp. Sta., by K. Ryerson (Pt. I) and M. E. Jaffa and H. Goss (Pt. II), 1923.

The lesson the avocado orchardist must learn from this is that the varieties must be so intermingled in the field that the protandrous [1] trees may be contiguous to protogynous [2] ones. Since the orchard is a collection of clons, or masses of individual descendants propagated vegetatively from the same ancestral tree, by planting out the rows and trees in accordance with the known varietal flower habits, which have been worked out for most commercial sorts by A. B. Stout, the grower can control this peculiar "self-incompatibility" defect and thus assist nature in producing full sure crops whenever tree vigor and weather permit.

The fruits vary from the very savory little Mexicans, with shining black rind, weighing only a very few ounces to the big Guatemalans, like the Tertoh, Spinks, and Nimlioh varieties, with green or purplish, woody, brittle, shell-like pericarps, weighing from 2 to 4½ pounds. The shape may be round, obovate, or pear-shaped; some varieties have a long curved neck at base. The oil-content of the buttery green and yellow pulp varies from 9.8 to about 30 per cent; there is neither starch nor sugar in evidence. This so-called oil is a very peculiar and unstable substance. The writer found [3] that the most practical method of extraction was to dehydrate the nearly but not quite ripe pulp, then subject it while hot to high pressure; with care to retain the pulp cake in the press cloths, a clear greenish-yellow, heavy, excessively dry-tasting oil may be obtained. There seems to be no hope now for utilizing this oil commercially, though soap can be made with it; in the fresh pulp it seems to be a highly nutrient food, but outside it is quite inedible.

There is a feeling among the medical profession that there is some subtle "toxamine" element in avocado pulp which affects some individuals adversely. Persons not accustomed to this fruit should never eat more than one a day. The

[1] Anthers mature before pistils in same flower.

[2] Pistils receptive before pollen is ripe.

[3] Tests at the By-Products Plant of the Porto Rico Dept. of Agr. and Labor, 1924.

Amerind people of Central America consume in season very large amounts of the delicious nutty-flavored pulp.

Thus far in the North American markets the avocado has been regarded as a luxury fruit for salads and special dishes, but a well-planned advertising campaign could probably put it into the food-fruit class, with bananas. This would relieve the rapidly increasing output of the California and Florida orchards, though the present high price would need to come down at least one-half. The surplus crop in some parts of the West Indies is wasted at times; at 50 cents to $1.00 a sack it does not pay to market them, and they are not much used for stock feeding.

Although the large ovate seed, in its loose or tight brown papery coat, contains much tannin and even indelible ink, goats eat it. A product resembling cotton-seed meal made by drying and grinding the sliced seed has been tested by the Porto Rican Department of Agriculture and Labor.

Theoretically fruit-flies could work in immature avocados: this may prohibit, by plant quarantine regulations, their exportation from tropical America to the United States markets.

The avocado offers great opportunities to the fruit-breeder. Once the interdependence of the principal orchard varieties is well worked out, so that every tree may bear at least one good crop a year, the acre yield will increase. The tight-seeded and the hard-shelled types will probably endure overseas shipment with very little loss. The selective trend will be not for very oily sorts with high caloric values (some now running to about 3000 a kilo) but for those types which have the delicate flavor of new walnuts and butternuts. Some of the small black fruits once tasted would out-sell the beautiful reds, whitish yellows, purples, and greens of ten times their size.

The avocado is one of the most promising new food fruits for warm climates, and unless some unforeseen cultural difficulties should arise the grower should have a comparatively easy task in working out a very good set of methods

and varieties, adaptable to each locality and in general highly remunerative.

The orchard practices suited to citrus trees apply in a general way to the avocado, but the latter is without question a more delicate species, both to propagate and to keep in a healthy condition in the orchard. Practically all the seedage and graftage methods in common use with oranges and grapefruit can be used with the avocados. However, citrus bark is easier to manage than that of the avocado, and greater care is consequently necessary in protecting avocado graft wounds from germs and water, a longer time for union is required and more care is needed in protecting the new bud-shoot.

Naturally, of course, the avocado is a much taller tree than any of the commercial citrus, but modern orchard methods indicate that the avocados can and should be kept down to easy picking height. Distance, therefore, may be about the same as in the case of grapefruit, 25 x 25 feet or a little more in heavy alluvial soil.

The avocado is now one of the principal salad fruits. Presumably, when production doubles and trebles, and perhaps doubles again, as it may during the next two or three decades, the price will fall within reach of the common buyers of food fruits. The avocado excels all other fresh fruits in the way of protein-content—from around 1½ to over 4 per cent—and can be compared to many of the dried fruits. It also carries a very fair supply of vitamins, and by reason of its remarkably high fat-content ranks about twice as rich in caloric value as the general run of fresh fruits. The banana will, of course, continue as a strong rival and the deciduous fruits and oranges will for many years hold the general public.

So much has already been done in the way of seedling selection and varietal study that it would seem almost unnecessary to hybridize subspecies and cross types, though this will undoubtedly follow. The one main point for the cosmopolitan pomologist to consider is the present surpris-

ing rarity of avocado varieties outside of the American tropics. There is a great field for expansion in the warm regions of both Africa and Asia, and although trials to date in those regions have been discouraging, there is no reason to think that the avocado will not be one of the five great food fruits of the tropics of both hemispheres within a generation.

THE SAPOTACEOUS AND RELATED FRUITS

Perhaps no other family of tropical fruits holds so much promise as the Sapotaceæ. There are at least 425 species and most of them bear edible fruits; their main stand is the Central and South American region. These trees have been furnishing food to the natives for thousands of years.

The sapodilla,[1] chico, or naseberry, *Sapota Achras,* is one of the sweetest and most wholesome fruits. The brownish granular pulp reminds one of a good pear sprinkled with spices and flavored with maple sugar. The Panama variety is the largest, the size of an apple. In the Philippines the chico is grown extensively, propagated by a kind of marcottage, branches one inch or more being rooted in position, then removed as long (5 to 10 feet) leafy cuttings. It is now common in India. (Plate XIV.)

The mammee-sapote, *Achras Zapota,* or *Calocarpum,* is a stately forest tree of wide range in tropical America. The oblong or ovate fruits, 4 to 8 inches long and half as thick, are covered with a rough brownish-red rind; the pulp is of a bright reddish or orange shade, sweet and spicy. It is usually eaten out of hand but is better with milk or cream. There is one large smooth seed, shining brown, with a hilum occupying one-third of its surface; roasted, it is used to mix with cacao in Central America.

The canistel, ti-es, or egg-fruit, *Lucuma nervosa,* is a native of Cuba and is now being introduced in other countries. The egg-shaped fruit is variable in size and form, usually some 2 or 3 inches long. The pulp is dry, granular,

[1] See Chapter on Tree Products.

sweet, and yellow, like a fruit-flavored egg-yolk. It makes excellent pies and jams, and is also very rich eaten fresh. An undetermined zapote, called jaune-d'oeuf in Haiti, has roundish fruits tasting like sweetened egg-yolk.

The zapote amarilla, *Lucuma salicifolia,* of Central America, resembles the canistel, but has larger fruits pointed at one or both ends; the pulp is exceedingly rich. This excellent fruit should be widely grown.

The sapote negro, *Diospyros Ebenaster,* of the related family Ebenaceæ, is a fine large Mexican tree. The large, mandarin-shaped, green-skinned fruit, 3 to 5 inches in diameter, contains a large quantity of black or dark brownish spicy sweet pulp. It is eaten fresh, out of hand, in milk or frappé with lime juice; and is made into pies and jams, usually with a dash of lime or orange juice. The Aztec name was tliltzapotl.

The mabolo, *D. discolor,* is a beautiful Philippine tree, very common through most of the 7,083 islands. The tomato-shaped fruit is the size of an apple and is covered with a reddish or brownish shining velvet usually in several shades on each fruit. The peculiar odor is not liked by persons unaccustomed to bizarre smells of fruits and flowers. The cream-colored or brownish pulp is almost too aromatic and sweet and dry. There are several varieties, one quite seedless.

The Japanese, or kaki, persimmon *D. Kaki,* is a temperate fruit. Some of the scores of varieties endure the higher elevations in the Philippines and South America.

The alakao, *Palaquium philippinense,* is a large Philippine tree with a sapodilla-like fruit.

The green sapote, *Calocarpum viride,* is a tree, native of Guatemala and Honduras. The luscious fruit, 3 to 5 inches long, is of various shades of green, thin-skinned, and oblong; the pulp is reddish-brown, sweet, less dry than most sapotes, and of a melting texture.

The lucmo, *Lucuma obovata,* is native to Chile and Peru, and was probably cultivated by the Incas centuries ago.

PLATE XII.—The Paheri mango, one of the best varieties introduced from India.

The fruit resembles the green sapote, but is smaller, round or ovate, and has yellow mealy flesh.

The abiu, *Pouteria Caimito,* of Brazil, Peru, and Colombia, is a small tree which bears excellent roundish fruits, 2 to 4 inches long, bright yellow outside and white within. This fruit is now coming into cultivation in the Amazon Valley and is already breaking up into numerous varieties. In some the pulp is translucent, sweet, melting, and very luscious, in others it is firm and mucilaginous with a sticky latex like that of the sapodilla. The nispero de monte, *P. tovarensis,* of Colombia bears golden-yellow fruits worthy of cultivation. There are thirty Pouterias.

The star-apple, or caimito, *Chrysophyllum Cainito,* is typically a West Indian fruit, but now scattered widely. The tree is one of the handsomest in the world; the slender graceful branches are clothed with leaves dark green and shining above and lustrous brown beneath; a puff of wind changes the aspect of the tree instantly. The fruit is nearly spherical, 2 to 4 inches in diameter; the thick fleshy rind is green in one variety, dull purple in another. The translucent pulp is arranged star-wise, the sections radiating from a small core. The rind is permeated with a sticky latex. The sections have a peculiar flavor, very sweet when allowed to ripen on the tree; a portion of the fleshy rind next to the sections may also be scooped or squeezed out and eaten, the taste being quite different from the gelatinous sections. Three or four other species of Chrysophyllum occur in the larger islands of the West Indies. The fruits, marketed in Dominica and eaten generally, are small but very sweet and tasty, usually purple or black, the juice being very "stainy."

The white sapote, *Casimiroa edulis* and *C. tetrameria,* is not a sapote since it belongs to the Rutaceæ, but in many ways it resembles the sapotaceous fruits. The tree of *C. edulis* is small, while the other species attains 30 to 50 feet. The Aztec name was cochiztzapotl, the sleep-producing sapote. It is also known as the matasano, or kill-health.

There seems to be no foundation whatever for these names. The grayish, brownish, or pale yellow fruit is tomato-shaped or roundish, very variable as to size and quality. There are several named varieties already, for its cultivation has recently expanded far beyond the highlands of Central America. The pulp is creamy, very sweet in some sorts, slightly bitterish in others.

The manik, *Bassia obovatifolia,* is a rare tree confined to a limited area in Luzon. The tall tree bears fruits resembling the sapodilla, but about twice as large. There are some thirty species of Bassia, or Illipe, in Malaysia and most of them are of potential economic value.

Several species of the genus Mimusops, common to both tropics, bear delicious fruits similar to the sapodilla. The pekola, *M. Kauki,* of Malaysia, is entering cultivation.

THE ANNONACEOUS FRUITS

The Annonaceæ with some 600 members is a very promising family for pomology. The public is fond of rich-flavored fruits with plenty of sprightly very acid juice. The pulp lends itself well to the preparation of iced drinks, sherbets, ices.

The cherimoya, *Annona Cherimola,* is probably the most ancient species. There are numerous types of this beautiful, luscious, and fragrant fruit and some are decidedly superior to others. Since a prehistoric race in Peru modeled terra-cotta vases from the cherimoya, it must have been in cultivation in that region when the great Sara (maize) was first found. It has now spread up through Central America to Madeira and the Mediterranean, to India and back by the African coasts to Argentina. Yet nowhere does it grow well at sea-level as it is a mountain species and will not stand hot nights.

The cherimoya is a small ungraceful tree or large shrub with narrow leaves 4 to 10 inches long, and fragrant flowers, 1 inch long and broad. The ovate or heart-shaped fruit may weigh from a few ounces to several pounds. The pulp is

white or yellowish, very aromatic and fragrant, and of a granular or custard-like consistency. Small orchards of cherimoyas are in evidence in several countries. The tree is as easy of cultivation as any of the citrus. It is often budded and grafted, but most trees are seedlings. The custard-apple is a good stock. If picked before ripening fairly large fruits may be shipped over long distances. The flowers are proterogynous.[1] P. J. Wester and Edw. Simmonds in Florida crossed the sugar-apple with the cherimoya, and the variable hybrids are named atemoyas; these have in turn crossed with other species. Safford recognizes five types based on the pericarp characters. There are perhaps fifty distinct forms.

A sub-species, the chirimoriñon, occurs about Caracas; the excellent pulp is surprisingly full of juice.

The sugar-apple, sweetsop, or ate, *A. squamosa,* is the most widely grown of all annonas. Its original habitat must remain a mystery: De Candolle considered it American, but it evidently reached south Asia before the great Portuguese and Spanish navigators, since it had names in Sanskrit and was represented in ancient wall carvings. One Mexican name is ata; the Philippine is ate; Safford suspected that the Malayan word atis (heart) was the original name, which was brought with the fruit to Mexico. This small (10 to 25 feet) tree is of the easiest cultivation under any reasonable conditions. It varies comparatively very little. The best sorts may be propagated by the usual graftage methods. The white, melting, very aromatic pulp is not very juicy but one of the sweetest of all the genus. It will not endure rough handling, the tuberculate pericarp easily breaking between the bosses, or section-caps of the syncarpium. The gray-green fruits with a whitish bloom, apple-size and -shape, are first-class breakfast fruits, fragrant table decorations, even good as food.

The soursop, *A. muricata,* is undoubtedly of tropical American origin; the common Spanish American name,

[1] Pistils receptive before the pollen is ripe.

guanábana, is supposed to be Quisqueyan (Santo Domingan Arawak). It is now grown in the Far East and in some parts of Africa. The tree is weak, not handsome, and practically always covered with scale insects. The fruit is of irregular shape, one-sided, ovate-oblong or cordate; weight from 1 to 10 pounds; pericarp granular-leathery, always green, and covered with soft short spines (at wide distances apart). The pulp is snow-white, a mass of soft cotton fibers; embedded in the fragrant, very aromatic, ice-cream-like mass are the dark-brown seeds. Soursop sherbet is probably not excelled; the pulp, with or without the seeds, in iced water makes a most refreshing beverage. Unlike the cherimoya the guanábana does not run to varieties. The vigor of the tree, the development of the fruit and its size are the main factors. Some of its hybrids may be worth exporting. (Plate XIV.)

The custard-apple, *A. reticulata,* is one of the commonest tropical fruits. Though forms of fair flavor are occasionally encountered, it is in general an insipid cloying fruit. The size is good, 4 to 6 inches in length, heart-shaped, whence the British West Indian name, bullock's heart, and the Brazilian, coração de boi. The color is good, reddish to pale purple or yellowish mauve, often with a lilac bloom. The pulp is white and nearly free from fiber, slightly granular toward the rind. It varies somewhat. The custard-apple is not an orchard fruit. It originated in tropical America.

The ilama, *A. diversifolia,* is a rare species of Mexico and Guatemala. The fruit is similar to the custard-apple, but is more rounded; the peel is greenish to mauve-pink and covered with a whitish bloom. Popenoe [1] states that this fruit "may be termed the cherimoya of the lowlands. . . . It is a valuable recruit and one which cannot be too strongly recommended for cultivation throughout the tropics."

The wild cherimoya, *A. longiflora,* is thus far practically confined to the state of Jalisco, Mexico. It resembles a very small cherimoya.

The soncoya, or manirote, *A. purpurea,* is a native of Mexico, Cen-

[1] Popenoe, W., Manual of Tropical and Subtropical Fruits," 1920.

tral and northern South America. The large fruit has soft orange-colored flesh of strong flavor. It will be used in hybridizing work.

The posh-té, *A. scleroderma,* a wild tree of Guatemala and Mexico, bears greenish fruits of medium size with a thick somewhat hard shell. The texture of the flesh is too solid to be perfect and the flavor rich.

The anona del monte, *A. testudinea,* of Honduras, has a fruit resembling the cherimoya but less aromatic.

The guanábano cimmaron, *A. Marcgravii,* of Venezuela, resembles the soursop, but is smaller and smoother; the flowers are very fragrant.

The manirito, *A. Jahnii,* is another Venezuelan species. It is a small tree with edible fruits.

Still another Venezuelan fruit of good promise, according to H. Pittier,[1] is the riñon, *A. cinerea.* The cherimoya-like fruit has unusually sweet pulp.

The alagadisso of Brazil and the countries to the southward is a spiny shrub with bright red fruits and sweet pulp.

There are several species of Uvaria in Africa and Malaysia which bear red or yellow fruits in clusters; few are cultivated yet, but some have delicious and fragrant pulp.

The biribá, *Rollinia deliciosa,* of Guiana and northern Brazil, is a tree of better appearance than the annonas. It has strange habits of suddenly throwing off all its leaves and of producing flowers and fruits at variable intervals. The fruit resembles the cherimoya in size, shape, and taste; the slightly tuberculate rind is greenish or yellowish when ripe; the white flesh is very juicy and aromatic. The biribá should be grown in quantity through both tropics.

The araticú do mato, *R. sylvatica,* is a Brazilian fruit, apple-size, with pulp like that of the cherimoya.

The araticú mirim, *R. laurifolia,* also of Brazil, has subglobose fruits with a white mucilaginous pulp of pleasant sweet taste.

The cachiman montagne, *R. Sieberi,* of Trinidad, has fruits like the sugar-apple, the sugary pulp melting in the mouth like ice-cream.

The anonilla, *R. Jimenezii,* of Costa Rica, also has fruits about like those of the sugar-apple, with white pulp.

Four species of Rolliniopsis in Brazil bear peculiar sweet drupe-like fruits in clusters, known as fructa de macaco, or monkey-fruit; *R. discreta* is orange-colored and pear-shaped.

Porto Rico has a wild cachiman, or biribá-like tree, *Rollinia mucosa,* with white, mucilaginous, sweet pulp. It is worthy of cultivation.

Perhaps the newly discovered fruit, closely related to the true

[1] Pittier, H., "Manual de las Plantas Usuales de Venezuela," 1926.

papaws of northern Bolivia, will stand at the top of the list of all the Annonaceæ; it has been named in honor of W. E. Safford, *Porcelia Saffordiana.* The fruits are said to run up to 45 pounds and are "highly prized by the natives."

MYRTACEOUS FRUITS

Perhaps no other family has so many species of fruits of dietetic value as the Myrtaceæ; the Rose family, of course, has the greatest number of varieties for it has been exploited and developed the most. There are two main pomological groups, the guavas with their relatives and the eugenias. The first is at present of more importance in commerce. The myrtaceous fruits are rather highly flavored, aromatic, fragrant, and juicy; they seem to have at least a medium amount of variability.

The true guavas belong to the genus Psidium; about 150 species are recognized by botanists, while the taxonomy of many horticultural forms is uncertain.

The common varieties are now nearly all included in the species *Psidium Guajava,* of which there are many synonyms. This tree was perhaps first domesticated by the pre-Inca people; the old Quichua name was sahuinto; guayaba was Arawak, and xalxocotl the Aztec name. It had probably spread all over tropical America before the arrival of the great navigators. It is now a common fruit in practically every tropical region, wet or dry, high or low. How much further these fruits will advance commercially cannot be foretold; the great natural advantage possessed by guavas lay in their acid-sugar-pectin balance; but now that concentrated pectin is being manufactured cheaply from both citrus fruits and apples, there is competition for the famous guava jelly and guava paste.

The tree is not ornamental. The bark sheds in irregular patches, like that of the allspice. The trunk, which is seldom straight, may attain 30 feet or more; but the wood is so good for fuel and charcoal that a tree is usually felled before it reaches full size.

The guava fruit varies from round to oblong, obovate,

and even pyriform. The rind color may remain green or turn yellow or even reddish; the pulp varies from white to red. The weight runs from 1 to 14 ounces, usually around 3 to 5. The flavor may be decidedly sweet (5.5 to 7.3 per cent sugars) or very acid. The odor of a very ripe fruit is not liked by many, but the ripening pulp has a very distinctive smell, which is shared perhaps by only one other fruit, the tabog (*Chætospermum glutinosum*). The seeds are numerous, horny, and objectionable. In factory practice the seeds are roasted, ground, and added to the "cheese," or paste, of the pulp after the juice has been expressed for the jelly. The acid and pectin are so strong that three times the weight of sugar may be added to the fruit: thus a hundredweight of fresh fruit yields about 350 pounds of jelly and nearly 50 pounds of paste, a gross value of some $200 on the $20 worth of raw materials. Hundreds of tons of this justly famous jelly are made in India, Cuba, and Florida.

Guava trees should be set about 12 by 12 feet; some may be cut out after a few years if there is crowding. The new method of propagation is to use large cuttings, 15 to 25 inches long, set half in the ground. Budding is too difficult, and seedage wastes a year or more.

An experienced orchardist can breed up the types of fruits desired by the factory.

The guavas are sometimes attacked by fruit-flies. The mummy disease is the most serious pest in tropical America. A fungus destroys the immature fruits, which shrivel, blacken, and remain attached. Bordeaux just before and some time after the main flowering period should control this.

The crop season is rather long and somewhat irregular, but very sure, in most guavas. Almost any soil except wet muck will do.

The fruit, in some varieties, may be eaten out of hand; all varieties make excellent preserves, pies, shortcakes, and jams.

The Strawberry guavas, *P. Cattleianum,* of Brazil, are better-looking trees than the ordinary species, and the fruit is one of the handsomest in the world. For some unknown reason these excellent plants have never become very widely cultivated. Native of Brazil, it was taken first to China, presumably through Portuguese Macao, thence, as the "Chinese" guava, to the Mediterranean countries. It is also known as the Cattley; it should be called by its first name, araça vermelho (red sour guava). There are yellow-fruited Strawberries, a form with elongated fruits, and large-fruited forms. It is hoped that this species will expand, for it is almost an ideal fruit: sprightly acid-sweet, fragrant, nutritious, and of highly attractive color outside and in.

The Costa Rican guava, *P. Friedrichsthalianum,* of Central America is similar to the common, but very acid. The pulp is white and melting. The native name is cás. It is worthy of extension as a jelly variety, having little of the strong aroma of the common.

The guisaro, *P. molle,* or chamach, of Guatemala has small, round, greenish or yellowish fruits, excellent for jelly-making.

The Pará guava, *Britoa acida,* resembles the true guavas. The white pulp has few seeds.

The feijoa, *Feijoa Sellowiana,* is a very fragrant fruit. This guava-like tree is native to central and southern South America but it is commonly grown now in California and the Riviera of Europe. The greenish, or partly reddish, oblong fruits are covered with a thick white bloom. The whitish translucent pulp has the exquisite blended flavor of the pineapple and strawberry; the bouquet of the ripe fruit is so penetrating that it clings for many hours to a basket or dish which has held them. Unfortunately the feijoa has three negative characters: it is not a sure cropper; it is difficult of propagation; and it does not come true to seed.

The rose-apple, *Eugenia Jambos,* was first cultivated somewhere in Malaysia; the Sanskrit word jambu was the old name in the East Indies, and it should have been kept

outside. The rose-apple is such a vigorous grower and so extremely easy of propagation that it has become naturalized in many regions. Its wood is valued in tropical America for charcoal. Sapling stems are cheap barrel hoops, tobacco curing sticks, and the like. The tree grows rapidly, attaining a height of 40 to 50 feet. All soils are acceptable. It is an excellent ornamental, due to its shining leaves and graceful habit. The fruit is nearly spherical, 1 to 2 or more inches in diameter, pale yellow, with large persistent green or brownish sepals, and the odor of fresh-opened roses. The pulp is granular, crisp, and juicy; there is always a cavity in the center, which the one round (or two half-round) seeds never fill. Like the mangosteen, lanzon, and guinep, the rose-apple may be eaten without stint. The delightful fragrance persists in the cooked pulp, jam, preserves, or as a crystallized confection. A perfumed aromatic sirup is easily made by straining out the pulp. There seems to be no real variation either in habit, leaf, or fruit.

One of the most promising of the eugenias is the Philippine duhat, *E. Cumini.* This beautiful tree grows 25 to 40 feet. The black or purple fruit is about the size of a grape; the pulp is of excellent flavor and is marketed in large quantities. It is a fine fruit for jellies, the beautiful color going through the cooking. There is a seedless variety and several sizes of the fruit.

The ohia or Malay-apple, *Eugenia* or *Jambosa malaccensis,* of the East Indies, is one of the most striking fruits of the genus. The tree has broad or oblong, thick, shining leaves; it grows rapidly, reaches 25 to 40 or more feet, and is excellent for windbelts. The fruit is variable; usually obconical, pear-shaped, or roundish; the common color is dark purplish-carmine. The pulp is snow-white with scarlet veins; the odor of roses is nearly as strong as in the rose-apple; and it endures cooking. By removing the large seed, slicing, and boiling the fruit without removing the thin peel, a beautiful amethyst jelly is obtained. Fowls are so

fond of it that they often fly up into the branches to eat the fruit. There is a sub-species or variety with a pale yellow or whitish pericarp. The large flowers, 4 to 5 inches across, with their numerous purple-carmine stamens are very ornamental.

Popenoe considers the pitanga, *Eugenia uniflora,* the best of all eugenias. The small tree is native to Brazil. The bright red fruit is eight-ribbed, about 1 inch in diameter, and nearly filled with the large seed. The sourish aromatic pulp makes up into sherbets, jellies and wines. There are several varieties. Pitanga hedges are becoming fairly common.

The pitomba, *E. Lushnathiana,* is another Brazilian fruit of considerable promise, similar to the pitanga. The 1-inch fruit is bright orange-yellow; the flesh is melting, aromatic, acid and juicy.

The makopa, *E. javanica,* of tropical Asia is beautiful but not very flavory. The conical fruit is pink, with a dry pulp.

The maigang, *E. polycephaloides,* of the Philippines, has small, dark red, acid fruits.

The onani, *E. lancilimba,* of Mindanao, has greenish-yellow, waxy, semi-translucent, acid fruits suitable for jellies.

The mankil, *E. Mananquil,* also of the Philippine Islands, has fruits nearly 2 inches long, borne in great profusion on the trunk and larger branches, ovoid, red, acid, and of good flavor and texture. This handsome tree deserves wide cultivation. It is one of the commonest eugenias of the Archipelago.

The grumichama, *E. Dombeyi,* of southern Brazil, is becoming popular in cultivation. There are three or more distinct forms of the cherry-like fruits.

The jambolan, *E. Jambolana,* of the East Indies, has long been in cultivation in many countries. There are several varieties of the oval, purplish-red, very acid fruits.

The pero do campo, *E. Klotzschiana,* of Brazil, is a striking fruit of much promise. The small shrub produces a fruit 2 to 4 inches long, somewhat pear-shaped, and covered with a sort of velvet; the pulp is soft, very aromatic, acid, juicy, and quite fragrant. It is just entering cultivation.

Another Brazilian eugenia of much merit is the cabelluda, *E. tomentosa.* The yellow one-inch fruits are juicy, subacid, and have a tough downy skin.

The uvalha, *E. Uvalha,* is wild and cultivated in south Brazil. The yellow or orange fruits, oblate or roundish, have a soft juicy

pulp with an intense but agreeable aroma, excellent for making "refrescos."

The guava-berry, *E. floribunda,* of the Virgin Islands and Porto Rico, has long been known for its dark red or blackish fruits of the size of a small cherry. The intense balsam-like aroma of the purplish pulp is hardly equaled by any other fruit; it is used in making jams, and formerly a heavy liqueur and a strong wine, very popular in Denmark and the neighboring countries, were exported from St. Thomas in large quantities. There are three or four varieties in the dry hills of St. Croix; these vary as to size and color, but all are intensely aromatic. Unfortunately this excellent fruit does not take kindly to cultivation.

Closely related to the eugenias is the genus Myrciaria of Brazil, which produces the jaboticaba fruits. *M. cauliflora* and two other species are cultivated and, in southern Brazil, also wild. They are medium to large trees. The grape-like fruits, purple and thick-skinned, are borne singly or in clusters, close on the trunk and large branches. The pulp is translucent, whitish or tinged with rose, juicy, and very agreeable. The jaboticaba is one of the most popular fruits of Brazil, but it is doubtful whether it will meet much favor elsewhere. It is eaten fresh, made into jams, wines, and the like.

FRUITS OF THE SAPINDACEÆ

The Sapindaceæ, or Soapberry family, has some 1,000 species well scattered over the globe. Many species bear fruits of first quality, some of the best nuts belong here, and many sorts of drugs abound.

The widest-known fruit of the family is the litchi, *Litchi chinensis,* of south China and Cochin-China. Although one of the most difficult of all tropical fruits to propagate, it is now common from India to Papua; it is still very rare in the New World, but some trees are fruiting as heavily as the best in the Orient. The great island of Hainan seems to be the focus of the litchi group; some thirty distinct varieties are reported there.

The fruit is very distinctive; it is roundish or oval, about 1 to nearly 2 inches in diameter, rose or red in color, with

a leathery or crusty pericarp covered with irregular, thick, scale-like areas; this rind becomes brown in drying. The pulp is translucent, like that of a Malaga grape, but better in flavor than most grapes, and fully as juicy. The seed is fairly large in most varieties; it does not germinate well. Propagation is, by marcottage or layering, very tedious and expensive; until some other method is found, the litchis will not be widely grown in the American tropics.

The tree lives to a great age, reaches 30 feet or more, and may bear up to half a ton of fresh fruit. In Canton the litchi has been canned successfully for years. Several varieties are dried, either sun or artificial heat being used. These fruits, with their raisin-like flesh shrunken inside the brittle shell, are exported all over the world. The annual crop in one Chinese province, Kwang-tung, is said to be 10,000 to 15,000 tons, worth about 5 cents a pound.

The pulasan, *Nephelium mutabile,* is native in Borneo and the neighboring countries. The tree is ornamental, especially when carrying its heavy crop of dark red or purplish-brown fruits borne in small clusters. These most delicious fruits are from 1½ to nearly 3 inches long by half that thickness. The thick rind is covered with soft conical fleshy spines. The pulp is of an indescribable flavor—all the juices of all good fruits blended into an optimum, richer than that of the litchi and rambutan. Half of the rind is twisted off in eating out of hand: kapulasan is the Malay word for twist. The seed is large and edible, fresh or cooked; it is very delicate, but can be made to sprout if carefully handled. There are several varieties, one, at least, seedless. It requires an even, hot, moist climate.

The rambutan, *Nephelium lappaceum,* of Malaya, is another worthy member of the Sapindaceæ, but not so good as the pulasan. The fruit is about the size of a large grape; it resembles the pulasan but has longer processes and is darker in color. Some fifteen varieties are known to the inhabitants of Malaysia, but no horticulturist has ever

studied them. They should be tested out and put within reach of all tropical planters.

The aluao, *N. xerospermoides,* of Mindanao, resembles the litchi in size and appearance. The pulp is acid and the seed large; but under cultivation it might rank with the other nepheliums.

The kuching, *N. malaiense,* of Malaya, is now being studied by the Philippine Bureau of Agriculture.

The longan, *Euphoria Longana,* was once considerably advertised but now is falling in favor. It is a native of India, probably, but now principally grown in south China; many small trees are in evidence in the neo-tropics. Several sorts, according to Meyer, are cultivated in China. The longan is preserved and thus improved, and is also dried.

The alpay, *E. didyma,* of the Philippines is a promising fruit. It resembles a small greenish litchi. The pulp is scant, but juicy, sweet, translucent, and of good flavor. This rarely cultivated fruit must be very popular, for Wester records no less than thirty-one local names in the principal dialects of the Archipelago.

The kalayao, *Erioglossum rubiginosum,* is a rare wild tree of the Philippines, bearing fruits like a small litchi.

Another wild Philippine fruit resembling the rambutan is the kamingi, *Litchi philippinensis.* The pulp is scanty, but the large seed is good when roasted.

The lunau, *Otophora fruticosa,* a shrub 10 to 15 feet high, native of the Philippines, is very promising. The small fruits "are borne in large panicles, up to 200 in a bunch," according to Wester. They are dark red to black, quite smooth, with a sweet pulp. The roasted seed tastes like a chestnut. It is productive and ornamental.

One of the giants of the Sapindaceæ is the siday, *Pometia pinnata,* of Malaya. The tree may stand over 100 feet high. The fruit is smooth, round or oblong, up to 2 inches long. The pulp is like that of the related pulasan, semi-transparent, juicy, sweet, aromatic, and very delicious. The rind is soft; and the rather large seed may be eaten boiled or roasted. There are presumably several varieties, but little pomological attention has been shown them.

The akee, *Blighia sapida,* is a native of West Africa. It was early brought over to the Antilles, reaching Jamaica, where it flourishes best, in 1778. The tree is only medium-sized, but very productive, and a beautiful sight when in full crop. The fruit is a three-celled capsule, about 3 inches long, reddish or yellowish-pink; when ripe the sutures open, exposing the three round black seeds and the arils at the

base of each. These arils are fleshy, whitish or yellowish, and brain-shaped—whence the Spanish name seso vegetal. When cooked the arils resemble an omelette, but have a peculiar nutty flavor which is relished as a great delicacy when well cooked with butter or oil. The akee does not vary. It is rare in the Orient and even in Central America. Every estate should have a small orchard of this fine fruit.

One of the commonest indigenous fruit-trees of tropical America is the genip or mamoncillo, *Melicocca bijuga.* The tree attains 50 to 70 feet and is of some value as a windbreak. It is practically non-variable. The fruit resembles a large green grape; the pulp is acid, translucent, and pleasant, and makes a delicious jam. A cattle feed may be made from the large edible seed and the pericarp, dried artificially.

FRUITS OF THE MELIACEÆ

The Mahogany family is not famous for its fruits, but there are several interesting members, out of the 600 or more, which merit horticultural attention. The santol, *Sandoricum Koetjapi,* a handsome large tree of the Philippines and the East Indies, bears heavy crops of beautiful fruits which, at least in some varieties, are among the most flavory and distinctive. The velvety yellow or brown fruits are usually mandarin-shaped, 2 to 3 inches in diameter, and so fragrant that many persons object to them on that account. The pleasantly acid pulp is better cooked than raw; in fact, few fruits make a better preserve or "dulce" than the santol. The white sections of pulp inclosing the seeds remind one of the mangosteen. There are numerous forms.

The kechapi, *Sandoricum radiatum,* is a sister species, of Malaysia. The fruits are smaller.

The bayanti, *Aglaia Harmsiana,* is a Philippine tree which bears beautiful round, velvety, bright red or russet fruits about 1 inch in diameter; the fruits have the taste of cranberries, and are one-seeded. Another species, *A. Everettii,* is the bobonao of Mindanao and the Visayas;

this tree has oblong orange-red fruits 2 inches long, with a grayish subacid pulp. Another, the manalau, *A. oligantha,* has acid juicy fruits borne in clusters, and nearly an inch in diameter. According to Wester there is a fourth economic species, the bulog, *A. glomerata.* This small tree produces attractive fruits, an inch in diameter, covered with an orange-red velvet and filled with edible pulp.

One of the best meliaceous fruits is the lanzon, or langsat, *Lansium domesticum,* of the Philippines and the central Malayan region. The tree is small to medium in size and quite particular in its requirements. It is probably a cultigen. The fruits are borne in grape-like bunches on the trunk and larger branches; the shape is oblong, about 1 to 1½ inches in diameter; the pericarp is grayish or yellowish, tough, and satiny; the pulp is whitish, translucent, subacid, and of excellent flavor. There are one to three more or less viable seeds; a seed-variety occurs in the coconut plantations of Laguna Province. The pulp may be cooked in various ways but it is usually eaten out of hand (Plate XXIV).

The duku (spelled doekoe in Nederland-Indië), *Lansium domesticum* var. *Duku,* is a very popular Malayan variety of the langsat, larger and better. Both these fruits require extra humidity and heat for normal behavior. The duku fruits are about twice the size of the lanzon, the best being nearly 2 inches in diameter, rounder and with thicker rind.

Another closely related fruit is the mamata, *L. dubium,* a small tree of the southern Philippines. The round brownish-yellow fruits have a subacid flesh.

THE BILIMBI AND CARAMBOLA

One of the most interesting of the very old Malaysian fruits is the bilimbi or kamia, *Averrhoa Bilimbi,* of the family Oxalidaceæ. This tree, a cultigen, has been grown for centuries throughout the Orient, in temple gardens and in fence corners; it stands 15 to 30 feet high.

The emerald-green translucent fruits hang in small

clusters from the trunk and bases of the branches, turning when ripe to a pale yellow color. They are nearly cylindrical, 2 to 4 inches long by about 1 in diameter. The jelly-like pulp is pale green and full of oxalic compounds which make it one of the sourest fruits known, except in the case of the rare sweet variety discovered about 1923. Though too sour to eat out of hand, even when fully ripe, the bilimbi is an excellent jelly fruit; it may also be preserved in sirup or pickled, like cucumbers. The pulp contains a few flattened seeds. There is almost no rind at all. It is a first-class "ade" fruit.

A sister species is *Averrhoa Carambola,* the carambola, a cultigen of unknown origin; the Sanskrit name karmara, however, indicates its ante-European introduction into India. The tree stands 20 to 30 feet high. The fruit is unique in shape, 3 to 5 inches long and very strongly three- to six-angled, which gives it the trade name of star-fruit from the radiate cross-sections. It is yellowish-green or light golden in color. The pulp is in most forms very acid, but some are quite sweetish and pleasant; the odor is strong when fully ripe, reminding one of the quince. A refreshing drink may be made with the juice.

The Chinese are very fond of the "yong-t'o," or foreign peach, and for many years they have canned it in the southern districts. It is also pickled, stewed, and candied; when nearly ripe it makes up into a high-flavored jelly.

The carambola was introduced long ago into Brazil, and it is now scattered over most of tropical America. It may become of trade importance. Dietitians may not favor its potassium oxalate content, but it is one of the oldest and widest known tropical fruits.

FRUITS OF CARISSA

The Apocynaceæ, or Dogbane family, has a questionable reputation as a fruit-producer. However, out of the 1,100 members there are quite a list of meritorious fruits.

The amatungulu, carissa, or Natal-plum, *Carissa grandi-*

PLATE XIII.—The avocado, one of the best tropical and semi-tropical fruits.

flora, is perhaps the most popular fruit of the family. It is a very spiny shrub, sometimes forming a small tree 20 feet high, and it is used for hedges: a ten-foot hedge is better protection against animals than a wire fence. The spines are like tempered steel, 2 to 3 inches long with two points (Plate XIV).

The fruit is roundish or oblong, bright scarlet, with a very thin skin and a whitish or reddish juicy pulp. With cream or milk and sugar, it makes a fair substitute for strawberries. The juice of the pulp is gummy. The carissa makes a good sauce or jelly, but is delicious eaten out of hand. The flowers are very white and fragrant, 2 inches across.

The karanda, *C.* (*Arduina*) *Carandas,* is a common fruit of India and Malaya. The spines of this species are not bifurcate, but they render the shrub impenetrable. The fruits are nearly an inch long, dark purple or black when ripe, with red pulp. They are used for pickles in India, but may be made into jelly or gooseberry-flavored pies. A sweetish form is the perunkila of India.

Another species of carissa, or karanda, is *C. Arduina* or *bispinosa.* It has smaller flowers than the amatungulu and the roundish fruit is only ½ inch in diameter.

FRUITS OF THE FLACOURTIACEÆ

The Flacourtiaceæ, or Flacourtia family, yields several very fair fruits, out of some 500 species. The colors and flavors are pronounced.

The ramontchi or governors plum, *Flacourtia indica* or *Ramontchi,* is now well established in most tropical countries, and has long been cultivated in southern Asia. It is a Madagascar shrub. The dark purple fruit, resembling a roundish plum, makes a fine jelly. Some varieties are sour, some sweet.

The lanagon, *F. Euphlebia,* of the Philippines, closely resembles the preceding species. The fruits are shining dark purple.

The Malayan louvi, *F. inermis,* bears bright red cherry-like berries, very acid and hence good for jellies.

The paniala, or rataguressa, *F. Cataphracta,* of India, is a small thorny tree which bears abundant crops of red or purplish berries suitable for preserves.

Still another species is the rukam, *F. Rukam,* of the southern Philippines. The small fruits are violet-colored, fleshy, and of good but acid flavor. Violet- and amethyst-colored jellies should sell better than plain red ones.

The umkokolo, *Dovyalis caffra,* is a spiny shrub of South Africa. The yellowish or greenish fruits are 1 to 1½ inches across; the pulp is yellow, melting, aromatic, and pleasantly acid, excellent for jellies and sauces.

The ketembilla, *D. hebecarpa,* is a sister species, native to Ceylon. This shrubby tree is very productive. The black or purplish fruits are velvety on the surface; the pulp is purplish or lilac-colored, very juicy and excellent for jelly or preserves. The crop period is very long. This plant should be in every tropical orchard. From its size and flavor it has been named the "Ceylon gooseberry."

Another curious nut- and fruit-tree of the Philippines is the pangi, *Pangium edule.* This tall tree bears large brown oblong fruits, 4 to 6 inches long, filled with a sweet, aromatic, edible pulp. The cashew-nut-like seeds must be steeped in water before eating.

THE PASSIFLORAS

The passifloras are neglected almost everywhere except in Australia. There are some 300 species in the genus and about 350 in the family.

The queen of them all, at least for size, is the granadilla, *Passiflora quadrangularis,* of tropical America. This giant vine grows rapidly, often ascending to the tops of trees 40 to 50 feet high. The stems are four-angled, coarse, and yellowish-green, like the large leaves (6 to 10 inches long). The beautiful flower is 3 inches or more across and very fragrant. The yellowish-green fruit is more or less four-

sided, 6 to 12 inches long by half that in diameter; the ends and the four angles are rounded. The fleshy pericarp is hollow, and partially filling the large cavity is the mass of flattened seeds, each in its sack of juice. The odor and flavor of this mass of juice-sacks are exquisite. Many eat the entire mass, seeds and all; some separate the seeds. The juice makes a superior "ade" or a sherbet. The fleshy rind, 1 to 2 or more inches thick, may be cooked with sugar and spice, or crystallized.

The purple granadilla, *Passiflora edulis*, of Brazil originally, is the widest-grown passiflora and the only one which has thus far been cultivated on a large scale and canned for export. This vine is common in the Orient but it has attained commercial success in eastern Australia. Grown on trellises, some 375 plants to the acre, two crops a year are secured with moderate fertilization. The fruit is oval, deep purplish when ripe, and 2 to 3 inches long; the rind is crusty and brittle; the pulp is acid, yellowish, and aromatic. It is usually eaten out of hand by removing a portion of the shell and stirring a little sugar into the pulp mass.

The parcha amarilla, or the yellow or sweet granadilla, *P. ligularis*, is a popular vine fruit from Mexico to the Guianas. For its delicate perfume and delicious flavor it deserves very much better attention than it has received. The reddish or yellowish egg-shaped fruit is filled with a very savory pulp mass, to be eaten fresh or made into a drink or ice. The tough hard shell endures shipment over long distances; the fruit dries up but seldom decays. The striking greenish flowers with their coronas of white, red, and purplish shades are alone enough to warrant the cultivation of this delightful fruit.

The sweet-cup, or water-lemon, *P. laurifolia*, is another cultivated member of the genus. The yellow fruits, 2 inches long, are acid.

The curuba, *P. maliformis*, of Colombia, and the parcho, *P. Manicota*, of Venezuela, are also of considerable value. *P. macrocarpa*, of Brazil, has fruits like the granadilla,

weighing several pounds; and *P. racemosa,* of the same region, is cultivated for its greenish-yellow fruits and beautiful red flowers.

FRUITS OF THE ROSACEÆ

The great temperate zone Rose family is not well represented in tropical pomology. The commonest fruits of this group are the two species of icaco, Chrysobalanus, or cocoaplums of tropical American lowlands. Two forms of the plum-shaped icaco are almost always found side by side, the black and the white. Each has a mawkish insipid flavor in the white red-streaked pulp; but cooked in sirup a delightful taste develops.

The tejocote of Mexico and the manzanilla of Guatemala are species of Cratægus closely related to the hawthorns and thorn-apples of the north temperate zone. The small apple-like fruits are extremely common and popular in the table-lands of the said countries. The large shrub or small tree bears profusely the yellow mealy-pulped pomes, with three large seeds. They are excellent for jams and "apple sauce."

The capulin, *Prunus salicifolia,* is a wild cherry of the mountains of tropical America. The maroon-purple fruits are ½ to ¾ inch in diameter; the thin but firm skin covers a pale green, juicy, sweetish pulp, which is good eaten out of hand or preserved. There is considerable variation in individual trees; cultivation will bring about distinct varieties.

The sansapote, *Licania platypus,* of Central America, is a tree 30 to 60 feet high. The fruit is large, 4 to 6 inches long, oblong, smooth, greenish-brown, containing a yellow, rather dry, sweet flesh. It is strange that this fine large fruit has not become widely popular.

Many species of Rubus are scattered widely throughout both tropics, and a good number will undoubtedly be cultivated just as are the many raspberries of the north temperate zone. Colombia and Hawaii vie with each other as

to having the largest-fruited species. The range of color and flavor in these tropical berries is more than would be expected. Some are yellowish-white, others purple or black, still others of queer shades of maroon; some are sweet and insipid, others sprightly sour. The canes of some species reach a height of 30 feet.

The ragini, *Rubus rosæfolius,* originally native to the Himalayas presumably, is now running wild in the Philippines, Porto Rico, Brazil, and other countries; in Porto Rico the bright scarlet or pink berries may be picked every day in the year.

The akala, *R. hawaiiensis,* of Hawaii, has very great merit. According to Rock, there are yellow and purple forms, and some of them have flavory berries 2 inches in diameter.

The pilay, *R. niveus,* of northern Luzon, has bluish berries, a very unusual color in the genus.

The Colombian berry, probably *Rubus roseus,* has been prominently mentioned of late. It is a blackberry. The berries from wild plants measure 2¼ inches long. The plant has survived the winter in the Puget Sound region when protected, although native in Colombia. See Popenoe in Journal of Heredity for May-June, 1920.

LEGUMINOUS FRUITS

One of the most famous of all tropical fruits is the tamarind, *Tamarindus indica,* of unknown origin. This dense-topped tree has such a close head of fine branches and dark green leaves that, according to popular repute, it is dangerous to tie a horse in its shade. The roughish brown pod is variable in size and shape, usually 3 to 5 inches in length by about 1 in width; the seeds vary from two to six or eight. The brownish pulp is a sort of granular paste with a few fibers; the analysis proves this to be one of the sweetest fruit substances, over 30 per cent sugar, yet it is considered one of the sourest. About 12 per cent of tartaric acid completely masks the sugar. The pulp paste,

separated from the seeds and the crusty shell of the pod, has for centuries been an article of commerce; it keeps indefinitely. A brine made from this pulp has so much tartaric acid in solution that in India it is used for preserving fish. A little of the pulp brings out the flavor if mixed with other fruits. A few spoonfuls of the fresh or preserved (with sugar) pulp in a glass of cold water makes a delightful "ade," reputed as good for the blood. In Taboga Island, near Panama, the writer found a score or more immense tamarinds with a sweet pulp. Wester reports sweet forms in the Philippines. Every tropical farm should have a few tamarinds (Plate XI).

The velvet tamarind, *Dialium ovoideum,* of Ceylon, is cultivated somewhat in Malaya. The short plump pods are borne in clusters, each fruit being about ½ to ¾ inches in diameter. The pulp in the brittle shell is mealy and acid-sweet. Another species, *D. guineense,* is the West African velvet tamarind.

A similar pod, one-seeded, filled with a farinaceous, fibrous, sweet pulp is borne by a related tree, *Detarium senegalense,* of West Africa.

The nam-nam, *Cynometra cauliflora,* native of India and Malaya, is a small tree having several trunks, like the logwood. The ill-seeming wrinkled pods are borne on the trunk and root bases. They are of all sizes from 2 to 6 inches long. The succulent greenish fleshy pericarp is sweetish or subacid, and may be cooked up like apple sauce.

Many species of Inga have pods containing edible pulp. Some of these, like the inicuil, *I. Inicuil,* of eastern Mexico, have pods 1 to 2 feet long by 2 to 2½ inches wide; the sweet aromatic white pulp has a few soft silky fibers. The guamá of the West Indies has similar but smaller green pods.

The Mexican camanchile, *Pithecellobium dulce,* has curved reddish pods with black seeds partly embedded in a white sweet pulp of good flavor, and very nutritious.

The kayam, or Tahiti chestnut, *Inocarpus edulis,* of Polynesia and the southern islands of the Philippine Archi-

pelago, has kidney-shaped pods each containing a large bean-like seed. If boiled before they become ripe, these chestnut-like seeds are very nutritious.

Besides the carob and the algarobs of Hawaii and Mexico, the pods of which are important cattle feed materials, there is an Indian species, *Prosopis spicigera,* whose sweetish floury pods are used for human food.

FRUITS OF THE RUTACEÆ

Besides the citrus group (treated in Chapter VIII) there are many other promising fruits in the Rutaceæ. One of the most interesting, perhaps, is the tulau, or patulautulau, *Glycosmis pentaphylla,* of the Philippines. This handsome shrub with its leathery dark green leaves and pink or pale reddish fruits should be widely cultivated. The fruits are borne in clusters, like small grapes, and are sweet and juicy; according to Wester a sirup, resembling honey in taste and appearance, can be made from them. There may be several varieties. Each province has a special name for this plant: it is called ginging by the Tagalogs, mayongtung by the Visayans, and mabutan by the Sulu Moros.

The elephant-apple, wood-apple, or vila, *Feronia Limonia,* of Ceylon and India, is a small spiny tree which bears a large, round, light-colored fruit with a woody shell. The mealy, sweetish, aromatic pulp has a great variety of uses, from making an "ade" to jelly, marmalade and medicine. The jelly resembles that from the apple and black currant.

The bael, *Ægle Marmelos,* of India, resembles the wood-apple in habit and fruit. The latter is of the size of a small pomelo and has a thin hard greenish shell. The pulp is perhaps unique: mingled with the pasty aromatic pulp is a "limpid, glutinous substance, which is esteemed," according to Macmillan, "for its well-known medicinal properties." This pulp may be eaten out of hand or made, as the specific name indicates, into marmalade and preserves.

The Chinese lime, or limoncito, *Triphasia trifolia,* is a spiny shrub 6 to 10 feet high, native of China but widely

cultivated in the Philippines. The berries are dark red, sweetish, and are candied; the Chinese are very fond of a resinous preserve which they prepare from them.

The tabog, *Chætospermum glutinosum,* is a loose-branched shrub of the Philippines. The oblong greenish fruits, if picked when nearly ripe and kept for a week or so, develop a strong guava-like perfume which is delightful. Wester omits it from his list [1] of the Philippine Food Plants but it has been distributed into the American tropics where it has fruited well for years. Presumably it will be used for giving the guava flavor to jams and jellies.

The wampi, *Clausena Lansium,* of Chinese origin, is a small tree which bears yellowish fruits about the size of a small lime. The aromatic subacid pulp may be made into preserves.

CACTUS FRUITS

One family of tropical plants has long been neglected from the pomological viewpoint, though it has attracted attention in both the north and south temperate zones. Roughly, the edible Cactaceæ may be put into three groups: the tunas, the pitahayas, and the pereskias. The first group is by far the most important; there are probably 100 varieties, mostly of the genus Opuntia, which bear edible fruits. These fruits vary from whitish to nearly black, and from 2 to 8 or more inches in length; they may be flattened, oblong, roundish, or pyriform. Besides their heavy (13 to 14 per cent on an average) content of sugars, there are gums and proteid substances which make tunas, as they are commonly called in Latin America, among the most nutritious fruits.

Considering the facts that opuntias prefer dry soils where few other plants can thrive, and that their pulpy fleshy "pencas" or joints are good forage provided their spines have been burned off, it seems strange that they have not

[1] Wester, P. J., "The Food Plants of the Philippines," Bur. of Agr., Manila, 1924.

been cultivated to a greater extent. The spiny forms are so hated and feared that the average farmer does not like to have anything to do with any member of the group.

Chemists should study the juice of tunas. If the best varieties yield (according to Griffith and Hare) 8 tons or more of fruit to the acre and if the juice has around 14 per cent sugar, these plants ought to hold a place in the world's sugar arena. In Mexico a kind of brownish "queso," or cheese, is made from some kinds of tuna; this keeps well and is nutritious. Sicily exports tunas to the United States.

The pitajallas, or pitahayas, are large fruits, usually pinkish or yellowish, with snow-white pulp filled with small black seeds. The genus Cereus has several excellent fruits in tropical America, as also Harrisia and Hylocereus. Most of the plants are strong climbers.

There are two or three pereskias. One, native of Brazil, *P. grandiflora,* is a very spiny shrub. The fruit is reddish and pear-shaped. *Pereskia aculeata,* the Barbados gooseberry, is a slender woody climber, some forms practically spineless. The gooseberry-like fruit is reddish-yellow or red and quite sour.

MISCELLANEOUS TROPICAL FRUITS

The ancient pomegranate, or granado, *Punica Granatum,* is common throughout both tropics and even extends well into the sub-tropics, but it is cultivated on a large scale only in California, and there more for its juice than as a fruit to eat out of hand. The amethyst-colored sirup is its main claim for horticultural attention. Presumably the ancient Levantine orchards and hanging gardens were full of varieties of this prehistoric cultigen. Babylon had beer 9,000 years ago, and colored drinks were fashionable. Seedless forms exist, but there is always an unpleasant astringency in the membranous partitions which run through the seedy endocarp. The roundish fruits are 2 to 4 inches in diameter. The scarlet wax-like flowers are handsome. Meyer found many varieties in the Shantung Province of

China; some of a pound or more in weight. There are probably about 100 varieties extant and undoubtedly many have been lost. The pomegranate belongs to the Punicaceæ, which contains only two species, one native to the isolated island of Sokotra.

Several species of Zizyphus of the Rhamnaceæ produce the jujubes of the Near, Middle, and Far East countries. They are native to Malaysia, but China has been cultivating some varieties, at least, for about 4,000 years. The number of varieties between China and Morocco may run into several scores. The elongate plum-like fruits vary in shape, size, and color somewhat. They are usually dried and treated like dates. The flavor is in most sorts agreeable. The sugar-content may run over 21 per cent. The jujubes are cheap fruits for poor dry lands.

There are several members of the Elæocarpaceæ in the tropics which bear edible fruits. The veralu, *Elæocarpus serratus,* is the old "Ceylon olive," a very fair substitute for the olive. Unlike that of the olive the veralu pulp is edible in the raw state. Another species, *E. edulis,* comes from New Guinea. The kumakun, *E. Calomala,* of the Philippines is a small tree which bears plum-like fruits, blackish or purple-red, with red flesh, rather dry and subacid.

The closely related Tiliaceæ is a wide-ranging family with a number of fruits, though many species are thus far known only to botanists. Many, of course, are bast plants. The baluko, *Grewia philippinensis,* is a Philippine tree, bearing cherry-like, yellow, velvety, subacid fruits of good flavor. The muling, *G. stylocarpa,* also of the Philippines, bears small pear-shaped yellowish fruits with an apple flavor. The phalsa, *G. asiatica,* of India and Malaya, is a large shrub. The fruit is a berry, sweet or subacid, dark blue, and very abundant. It may be eaten out of hand or preserved. The barobo, *Diplodiscus paniculatus,* is a handsome Philippine tree which bears large clusters of starchy seeds which are boiled and eaten like lima beans.

The lingaro, *Elæagnus philippensis,* is a tropical mem-

ber of the Elæagnaceæ well worthy of cultivation. The pinkish or pale red fruits, 1 inch long, make a good high-colored jelly.

There are few better nuts than the very rare galo, *Anacolosa luzoniensis*, of the family Olacaceæ. This small tree is endemic in the Visayas and Luzon. The filbert-size nut is inclosed in a thin shell; the flavor is peculiar, somewhat like sweet-corn and chestnuts mixed. It should be cultivated throughout the tropics. Wester states there are several other Anacolosas, "the nuts of which are probably also edible."

The buol, *Ximenia americana*, is a large spiny shrub, also belonging to the Olacaceæ. It has a strange distribution: wild in the Philippines, yet an American species. The fruit resembles the jobo and ciruelo but is not related. The pulp is pleasantly flavored, acid, juicy, in a greenish-yellow skin.

After seventeen years the tabú has been brought into cultivation. The genus is not known but it probably belongs to the Sterculiaceæ. It is reported "to grow on a vine in the mountains of southeastern Palawan in the western Philippines." The fruit is, according to Wester, "of about the size of a small pomelo, smooth, with a thick rind and white, subacid, juicy flesh of refreshing flavor and excellent quality, containing several rather large seeds."

CHAPTER XII

THE COCONUT

THE coconut is the world's most important food tree-fruit. No other tropical crop comes so close to being indispensable to the human race in limited areas, in islands particularly. Coffee and the grape are greater in international trade, but they are essentially beverage crops. Bananas are very important and the deciduous fruits bulk large. Rubber is worth about twice as much in trade. However, 300,000,000 individuals use the coconut in some form almost daily, and about 500,000 tons of coconut oil are consumed in the north temperate zone.

ORIGIN AND BOTANY OF THE COCONUT

Perhaps of no other great crop is the origin shrouded in so much mystery. With the possible exception of a similar African species, all the other members of the group which includes the coconut are American. The coconut, in many varieties, was widely distributed throughout the tropical orient centuries before any Spanish or Portuguese trader could have brought it to the New World or taken it therefrom, yet there is no evidence to show that the coconut had ever been recognized in the western hemisphere before the Spanish priest, Diego Lorenzo, took it from the Cape Verde Islands to Porto Rico a little before 1525. Cook has contended[1] for an American origin for the coconut.

[1] "The Origin and Distribution of the Cocoa Palm," O. F. Cook, Contrib. U. S. Nat. Herbarium, vii, 257-293 (1900-2), and "History of the Coconut Palm in America," *ibid.*, xiv, 266-342 (1910). Opposed to this view are the studies of the palm authority, Beccari, who considers that an Asiatic or Polynesian origin is more probable than an American (Philippine Journ. Sci. xii, 27-43); see also the extensive paper by Emilio Chiovenda in Webbia, v. (1921).

The genus Cocos is now considered to be monotypic. The coconut, *C. nucifera,* is the only economic species of the sub-family Cocoinæ of the Palmaceæ. Since Linnæus, in 1753, erected the species no one has tampered with it, although some attempts have been made to create subspecies. There are some twenty-five or more distinct varieties of about five types, in three or four botanical varieties.

The very name coconut is shrouded in mystery. English has merely taken over intact the Portuguese word, coco, which was obviously slang coined by some old traveler, who, perhaps, went around the Cape with Vasco da Gama. The name was occasioned by the three "eyes" at one end of the shell and the fancied faint resemblance to a monkey's face. The Sanskrit writings, it seems, did not mention the coconut. In modern India it has many names, thenga, tennai, nawassi; in Ceylon it is pol; in the many Malay countries it is usually called n'yur, nyug.

ECONOMIC STATUS OF THE COCONUT

Although the plantation value of the 10,000,000,000 nuts is hardly over $200,000,000 a year, the trade value is probably twice that figure. Since the average yield of a palm is between 20 and 25 nuts, the world over, there must be around 6,000,000 acres planted—quite a proportion not yet in bearing—because the number of trees to the acre runs from 50 to 125 or more. The number of trees, therefore, in crop must be around 450,000,000 to 500,000,000. At $4 a tree the world's coconuts are worth nearly, if not quite, $2,000,000,000. The numerous copra and oil factories depending largely on coconuts, the warehouses, and the shipping are probably worth another $500,000,000 or more.

Accurate figures as to where coconuts are grown are not easy to obtain, but the following estimates are fairly correct for the period 1922-27; Ceylon is reported as producing 2,200,000,000—which may be too high; Dutch Malaya is supposed to turn out only 1,300,000,000 nuts, which is probably decidedly too low; the Philippines are listed for 1,500,-

000,000, but the figure is probably around 2,000,000,000; British India with 1,600,000,000 and British Malaya with 400,000,000 equal the three other regions. Polynesia, Melanesia, and Queensland together total nearly 1,000,000,000. Tropical America yields 200,000,000, only 2 per cent of the crop. Africa has probably rather less than that, say 180,000,000. Mozambique has greater potential expansion than any other country except the Congo, and some of the largest groves are already located there. In the western hemisphere Brazil and Trinidad each are supposed to produce between 35,000,000 and 40,000,000 nuts; Jamaica comes next with about 30,000,000; Panama and the 365 San Blas Islands, 25,000,000; then Porto Rico with 20,000,000 or, with a good season, 22,000,000; and Honduras, with around 15,000,000. The western hemisphere will perhaps never produce more than 4 or 5 per cent of the world's coconuts.

Copra, the dried meat of the nut, is largely responsible for the great extension of coconut culture in the last thirty years. The practice of shipping the oily endocarp away from the plantation was encouraged by the European oil mills, for although there was (and is) a serious loss from molds en route, the poonac, or press cake, paid the freight halfway around the world. The European demand kept increasing and before 1900 the Malayan countries, the Philippines, and India and Ceylon were rapidly extending their groves. Then, about 1909, oil mills began to spring up here and there in the Orient and when the Great War came and bulky cargoes had to be left, the price of oil machinery soared almost beyond reason; fortunes were made by the mills that got a good start; they bought the local copra at their own price and sold their coconut oil at about three or four times its cost. The storage question was serious; finally, during the War, tank steamers had to be used for the first time to handle the flood of oriental oil. The industry is quiet now. Local plants compete keenly with American and European mills. Both copra and coco-

nut oil go both ways out of the Orient, and this is well. The desiccated coconut business, which was for many years largely confined to Ceylon and New York City, has spread. Much oil cake has been wasted and used as fuel in the copra mills, but now it is a solid commodity in great demand wherever feedstuffs for cattle are used.

Coconut sugar has not yet entered the markets, though much is consumed locally. Coconut alcohol, likewise, has scarcely progressed beyond the experimental stage. The production of tuba, or coconut sap, in the Philippines is some 25,000,000 to 30,000,000 gallons a year, and a gallon of tuba contains more than a pound of sugar.

Fresh nuts are not so important as they appear. Hardly 100,000,000 are marketed as such. Considerable copra is now being made in the West Indies.

Coconut culture seems to be slowly extending in some localities; in a few others these palms have been destroyed to make room for rubber.

The status of most of the coconut groves of both tropics is low. The average tree yield is about one-third of what it should be. The main causes are: almost utter lack of seed selection; over-crowding of trees, many groves carrying a stand of 200 to the acre; bad sites, soil too wet or too shallow or too severe droughts; scale insects, fungous leaf-blights; grass and weeds which stunt the young trees; lack of green-manures and fertilizers. Much could probably be done by changing the varieties; at present about 99 per cent of the total crop is produced by the old Green and Yellow varieties, one about as common as the other. Not 2 per cent of the coconuts standing today are grown from selected seed nuts. Probably 75 per cent of the groves are owned by natives.

The principal rivals of coconut oil in commerce are cottonseed, peanut, palm-kernel, soybean, sesame, and palm oils in about this order of importance. Corn oil from United States maize may become a prominent factor; and Argentina, South Africa, and Brazil may, with the new processes

for manufacturing maize sugar as well as oil, starch, and the like, upset the oil markets of both Europe and America.

Not only cooking oils and blended fats but even "butters" are made on a large scale from copra; the bakery and confectionery trades are somewhat dependent on the coconut. The technique of obtaining an excellent wholesome butter, white and tasty, from the odorous copra, covered with green, brown, and blue mold, and full of rancid fatty acids, is really marvelous. No other crop offers such a field for industrial chemists as does the coconut; cotton-seed and maize have had the benefit of a host of experts.

CULTIVATION OF COCONUTS

There is an old superstition that the coconut likes the sound of the sea; and many millions of dollars have been wasted on that account, for in very many cases the prospective planter has left rich alluvial lands behind to take up a nearly worthless piece of sand near the ocean. Many persons have sprinkled salt into the earth over the roots of the newly-planted tree and a few still believe that salt actually acts as a fertilizer to coconuts. The best and biggest area of contiguous coconut plantations in the world (Laguna Province, Luzon, Philippine Islands) never has felt a breath of sea air. Likewise in the interior of Central America, sometimes up to 2,500 feet elevation, the coconut does well.

The peculiar cord-like roots, 5,000 to 7,000 or more, radiating out from the bulb-like base of the bole, cannot penetrate hard clayey soils. Since most of the good mellow soil in the tropics is either along water-courses and very valuable or along the strand, the coconut is usually relegated to the poor sandy stretches near the sea. One may read that the coconut is so fond of the sea that it will even reach its roots out under the waves. If there are any live roots below salt-water level it is certain that there is a strong flow of fresh water through the soil into the sea below the surface. Any soil of three feet depth which is

PLATE XIV.—*Left:* in bloom and fruit, amatungulu (*Carissa Arduina* or *Arduina bispinosa*). *Center:* sapodilla (*Sapota Achras*). *Right:* soursop (*Annona muricata*).

loose and open is suitable for the coconut, provided the water-table does not come within two feet of the surface, and there is no poisoning effect of salt or brackish water, and that the elevation is less than 2,500 feet.

A few degrees of frost kills the young leaves, yet Florida grows thousands of these palms. The more humidity, the better the coconut thrives. The best groves in some respects are those in southeastern Nicaragua, where the rainfall is around 300 inches a year. Thirty-five or 40 inches is probably the minimum; 75 inches is perhaps the average for groves in good standing.

Coconuts will stand even hurricanes if not too violent. One author once propounded the theory that wind movement was really necessary for coconuts—to cause a strong evaporation from the leaf surfaces, which would create a partial vacuum in the tissues and therefore pull up the sap through the long trunk. Young palms should be protected till well rooted.

Transportation of nuts or copra is a heavy task; but where there is sufficient area to start a plantation, there must surely be some sort of road or water route to serve for the movement in and out of materials. Many coconut groves are water-served, especially in the East Indies, the Philippines, and East Africa. The grove may be located even in a swamp, provided it is drained and the salt water kept out, as is done in British Malaya with a system of concrete drain-gates which let out the surface fresh water at low tide and, automatically closed, hold back the brackish water at high tide. The requirements of the coconut plantation are loose well-drained soil, no salt, a fair amount of rainfall evenly distributed, and reasonable means of transportation.

Raising the seedlings.

One of the main reasons for the low average yield, under 25 nuts, of coconut groves is that the nuts for the seed-bed were not obtained from the best trees, those which always

yield a good crop of well-shaped heavy nuts. The husk of a good nut should be just barely sufficient to protect the shell from breaking when the ten-pound bomb crashes down from a height of 60 feet. Every extra inch at the distal end or on the circumference is not only waste but it means more time in freeing the shell, no inexpensive item when husking several thousand nuts a day by hand. A short heavy nut is the best for the seed-bed, and only from good-performance trees.

Partial shade, to prevent sun-baking, is recommended for the seed-bed. If no trees are available to protect the bed from the noontime heat rays, straw, leaves or even sand should be spread over the nuts. This blanket retains most of the soil-moisture, without which the stem-scar cannot absorb the necessary quantity of water to stimulate germination of the one good eye in the basal end of the shell.

The nuts, after a final inspection, are laid intact on their sides as close as desired, preferably in triple or quadruple rows, with narrow walk-ways between; the back of each husk should show well above the soil surface. If the weather holds dry, the bed must be kept moist—not too wet—at all times.

About 95 per cent of the seed nuts should germinate within four or five months. The first root leaves the base-scar, going downward, a little before the green cockade comes out above ground.

When the sprouts are 6 inches high they go either to the grove or to the nursery, if the grove is not ready. Most planters wait too long before they remove the sprouted nut to the field. The stored-up food supply, given by the mother tree to carry the young palm through the danger period of infancy, will last for about a year. Then comes a danger period when the seedling has neither food reserve nor sufficient roots and vigor to endure shocks. The cotyledon, or spongy "embryo-foot" which grows from the eye

back into the cavity of the nut, absorbs gradually the oils and sugars of the meat, digesting them with enzymes and passing them out through the quarter-inch opening to the hungry young leaf-bud and the thirsty roots.

The seed-bed is usually forgotten for the better part of a year or so, till it becomes a nursery of young palms 3 or 4 feet tall. Then the planting gang grabs the spindling palms by their leaves, yanks them out of the bed, and hustles them off half a mile or so, uncovered and drying rapidly, to the new field. Every root is broken or cracked at or near the point where it left the husk, the slender wiry core of each root just holding the spongy pieces together. It would be better to snip off all these broken roots at the husk and let new ones grow out, in time, after setting into position. The coconut has no tap-root. The roots are brittle, about ⅛ inch in diameter throughout their whole length. At intervals they put out fine wiry feeders, and near the large spongy tip there are many queer whitish spots, valves through which air, and perhaps soil solutions, are admitted into the circulatory system. The short adventitious roots which usually are seen at or above the bole base are indicative of a lack of air in the soil. Arrived at the hole, half dead from wound shock and sun drying, the seedling is set any way, husk still attached, into a half-made shallow pit. It is no wonder that the young trees put out no new leaves for six months after leaving the seed-bed nursery. This is the way 95 per cent of the coconuts are planted.

Planting.

There are numerous ways of planting coconuts. A pretentious grove in the big Loiza district in northeastern Porto Rico has trees 30 feet apart, square system, giving only some 48 trees to the acre; in this method 30 per cent of the area is wasted and the total number of nuts to the acre (not to a tree) is extremely low. Another grove in the famous San

Pablo district of south central Luzon, is a jungle with 275 healthy trees to the acre; the yield of a tree is very low, but the tremendous number of trees, multiplied by the individual contribution, gives two or three times the quantity of nuts obtainable from the grove of the great open spaces. In eastern Cuba coconuts are scattered helter-skelter on rocky hillsides, and in Malaya are set up on black mud ridges with oozy ditches or canals criss-crossing through.

The best arrangement is to set coconuts about 25 feet apart, square, or 28 feet, quincunx; about 70 to 80 trees to the acre. On poor soil the weaker smaller trees may stand closer. In the 30-feet deep alluvium of the Zambesi valley or the Greytown, Nicaragua, region there must be allowance for 70-foot trunks, 170-nut yields, and leaves 25 feet long. A pioneer planter on Negros Island in the Philippine Visayas sets them wide, feeds them generously, numbers each tree and books its performance like a record cow: he is not quite satisfied unless he gets a pikul (133 pounds) of copra to a tree, *i.e.*, 250 to 275 nuts a year, or ten times as much as the average tree produces.

Coconuts may be set in rows to improve the appearance of the grove, but for no other reason.

The bigger and deeper the holes are dug, the better. They should be not less than 2 feet square by 1½ feet deep or a 3-foot circle, better a bit wider and deeper if a few nuts are expected the fifth year. The hole should be filled with the best surface soil to be found within reach of the mattock. Unless the water-table is high, it is well to set the nut, just beginning to sprout, quite low in its soft spacious bed, taking care that no strain, from seed-bed to hole, has injured the weak spot where the husk is attached to the sprout. A few months after setting, a few more inches of earth are hoed onto the old husk. This method gives the tree a firmer anchorage, which may make a big difference in very windy locations.

Care of the grove.

The infant palm recovers from the shock of planting in a few weeks. In one year the coconut should stand 6 to 9 feet high and be ready to begin forming a trunk. This will not occur, however, unless the weeds are kept down around the seedling for the first two years. The radius of the weed-free loose-earth circle around the young tree is practically always too small. Circles, to be effectual, should extend out as far as the tips of the leaves, because the roots are out there, probably even longer than the leaves if the soil has been penetrable.

Live mulches have only recently been planted in young coconut groves. Millions have been lost through not keeping down grasses and plant-food robbers crowding and checking the young palm. The best help-crop to make a living cool blanket around the base of the coconut is for the field superintendent to determine. It should be a legume, a plant which will furnish nitrogen in its root-nodules to the soil and make it richer instead of poorer, as cowpeas, beans, pigeon peas, peanuts, the bush form of the velvet bean, horse beans. Quality of soil, amount of rainfall, and the like, are determinant factors. A little cash may be secured from secondary crops if edible varieties of beans and cowpeas are planted and properly harvested.

The problem of what shall be done with all the waste space between the coconut rows in a young grove is perplexing. No two groves have the same conditions in this respect, therefore no rules can be laid down to fit all cases. In some localities the field should be left intact, since it has probably never been plowed, with an occasional disking or cutlassing to keep down the brush, at least, till the palms take over most of the interspace. In the Philippines abacá (Manila hemp) may be set, about five hills in each, in the open spaces, and after the first year a very fair return in fiber should be expected up to the fifth or sixth year. In tropical America, Africa, and the Orient, numerous intercalary crops may be cultivated profitably for the first six

years. Maize is a general favorite, and justly so, its roots being perhaps less poisonous to the higher plants than those of any other grass. Bananas are cumbersome, even the dwarf Chinese and the Date varieties, but frequently profitable. Sweet potatoes, ginger, dasheens, yautías, yams, pigeon peas, even cassava if carefully kept in bounds, and many others may fit in exceedingly well. Three things must always be borne in mind when putting in catch-crops: the money value of the secondary produce, the lessening of weed dangers, and the maintenance of healthy soil conditions so it is ready for occupancy by the rapidly extending coconut roots. The proper balancing of these positive factors against the cost of cultivation for the secondary crop (generally greater than that of the clean-cultivation system) and the largely theoretical danger of robbing the soil of food elements due for consumption by the original crop, is a problem.

In general, a light harrowing two or three times a year, when no secondary crops prevent, will control most of the weed troubles, aerate the soil, and (in drought-time) check evaporation. Weeds and brush must be kept down unless a retarded growth of the main crop is tolerated. Deep plowing with tractors and disk-gangs is dangerous. Of course a tree whose feeding roots have just been mangled will react visibly, throwing new leaves or flowers promptly. Hoeing and scuffling the circle occasionally when it is not growing a secondary crop is good for the coconut.

Ditching and draining must be attended to when the water-table encroaches on the root-realm or when the run-off is lazy in dank lowlands deluged with four-inch rainstorms. It must be remembered that sour soil is one of the few evils that the coconut cannot endure.

Mulching is recommended where cheap material, like cane trash from near-by fields in the cutting season, is available. A good cool root-blanket of a straw mulch is better than a weedy live one.

Removal of old trees which have ceased to give profitable

crops is best accomplished by means of a short well-sharpened cross-cut saw; the choked and mineralized tissues at the trunk base are too hard for an ax. The felled trunk should be sawn into lengths; these may be used as bait for palm beetles.

A good fertilizer ration for a young palm just coming into bearing is 8-10-12; more nitrogen if there is a dearth of legume cover-crops, and more phosphoric acid if the planter desires to hasten the harvest. Three to 5 pounds to a tree, spread well away from the trunk, every four to six months, applied at the end of the rainy season preferably, is perhaps the optimum; at two cents apiece it does not take many of the extra nuts to repay this outlay. Coconuts enjoy a reasonable amount of humus. Legume cover-crops may be slashed down or their tops lopped off, if of the pigeon pea type, or any material, from bat guano to sea-weed, that will soon rot and produce no unwholesome ingredients may be applied.

HARVESTING COCONUTS (PLATE XV)

The first flowers should appear the fourth or fifth year; many, if not most, coconuts hardly start producing their seventh. At twenty to forty years the coconut is in its prime; from then till the base of the bole chokes up with mineral matter deposited in the purplish fibro-vascular bundles, say at sixty to eighty years, the yield may come down gradually.

As crop trees go the coconut is remarkably regular in yields; not only even, year in and year out, but not much variation in the monthly yield. A severe drought reduces the next year's crop, of course. Counting trees the world around, native groves (comprising probably 75 per cent of the total) and estates yield a yearly average of between 20 and 25. The yield of a fairly well tended tree, not crowded, not fertilized, in a fair site, is from 60 to 100 nuts. Well-cared-for trees give 75 to 200 or more nuts. The exceptional tree standing where it has plenty to eat and

drink may mature 300 nuts and drop many immature ones. A tree in Surigao, Mindanao, is said to have been carrying 470 nuts of apple size and upwards, and vague reports of 500 nuts have been made, twenty times the general average. The seventy trees on an acre should yield from 4,000 to 6,000 nuts, which means 1 to 1½ tons or so of copra and a little over one-half as much oil. A ton of copra, the object in most cases, should be worth, ordinarily, at the plantation from $75 to $125 in coin of the respective realm or in trade goods.

Ways and means of getting the nuts down range from waiting till they drop, when the husk is dry on the surface (Central America), to sending a trained monkey with string attached up to twist them off (Straits Settlements, but more for show than regular business). Most nuts are climbed for and, as would be expected, climbing tall trunks three or four times a year, 50 to 100 trees to an acre, is not easy nor cheap, nor conducive to long life. There are three ways of aiding the feet and legs, of easing the strain on back and thigh muscles, by means of thongs or bands; but many expert climbers rely only on their tried and true sinews and muscle. The picker seems not to dread a fall so much as the stings of wasps.

In Malaya the astute Chinese coolie sometimes rigs up a bamboo pole (two spliced end-to-end for the old trees) with a short, stout, curved knife at the tip. It is interesting to see the blade grope around the close-packed bunch till it can be hooked over the pedicel of a nut, then the breathless seconds while the ten-pound missle hurtles down almost onto the head of the stolid squinting picker.

In Nicaragua, where it rains twenty-five feet a year, the nuts do not sprout if left on the tree till they drop, whereas in Malaya nearly one-third would start to sprout in position unless hand-gathered.

Usually the nuts are collected into large heaps, 10,000 to 20,000, in the shade of old palms or under sheds, and there they remain drying out from a few days to several weeks

till the huskers shell them and pass them on to the laborers who take the husked nuts by cart, boat, or truck to the copra shed. In the rather insignificant coconut districts of the western hemisphere they may go direct to the dock, 75 to 100 in a sack. The nuts ripen up better after picking if left in the husk for a time. If the husked nuts are left a few hours in the sun, the shells crack, which spoils them unless "worked up" at once.

There are many huskers. Most nuts are pushed onto a stake of very hard wood set firmly in the ground. Frequently the sharp point of wood is replaced by or shod with a cap of iron or tin or a plow-point. In Melanesia the husky blacks manage to get off the fibrous coat with a sharp wedge-pointed wooden sword or broad spear. In tropical America most are husked with the machete. In some few places long-handled tongs are used to advantage, something like a blacksmith's shoe-tongs: the closed jaws (about 2 inches wide) are driven down into the husk, the husker standing erect, and the handles are then slightly opened, which splits open the husk at that point; some three or four thrusts are required to separate the bulk of the husk from the shell: a boy or helper, seated, should then pull off the small strips of fiber which the tongs necessarily leave sticking to the shell. By the latter method a fairly strong husker can alone finish around 1,000 nuts in a day; with a stripper to clean the shells he can handle 50 to perhaps 75 per cent more. A machete or a plow-point husker can strip anywhere from 500 to 1,500 nuts depending on size, condition of husk, and the like. Expert Filipino huskers claim about 3,000 as the best that can be done.

Machine huskers have been invented and even tried, but there is usually some serious fault with the power or else too much skill is required to operate. In this connection it must be remembered that no two coconuts are of the same size and shape. A fortune awaits the inventor of a simple, cheap, and efficient mechanical husker.

Occasionally the nuts are not husked at all, just chopped

open with some sort of a big broad-ax. The meat clings very tightly to the freshly opened shell, however, unless it has been steamed, and therefore the chopped-open nuts have to be laid out in the sun till the meat shrinks somewhat away from the shell.

COCONUT PRODUCTS

Copra.

Probably 80 per cent of the coconut crop is made into copra. There are three ways of drying coconut meat and many modifications of each. The primitive, and still very common, method is to crack the nuts open, around their equator, and set the half-shells out in the sun, preferably on a paved floor or on matting, for a day or two, then remove the shrinking meat in pieces, say three to five pieces to each half nut. These pieces are then spread out, sometimes in a nearly clean place, in the sun, for another two to five days, according to the amount of sunshine. It is amost impossible to get the moisture-content in sun-dried copra down to 10 per cent; which means that two if not three species of molds will attack the sweet inner surface of the pieces, destroying a very considerable portion of the oil-content before the bag, stinking and reeking with rancid oil, emitting clouds of yellow, brown, and green spores whenever moved about, can reach the oil-mill where the beautiful, delicious and wholesome butters and edible oils are turned out.

The kiln-drying method is in some ways worse than the sun-drying. It gives an uneven product; some pieces go into the sack burned while some are raw. Very commonly smoke is allowed to permeate the whole mass of the meat pieces spread, or rather piled, on the grill or grate built over the fire-pit, which may be sunk partly below the surface of the ground. Smoke, of course, has one important effect on the copra: it, or the so-called "creosote deposit," does hinder, if not prevent, the growth of the molds on the imperfectly dried meat. On the other hand, the factory

staff does not relish creosote, and it takes a fine technique to keep it from tainting the hundreds of thousands of tons of food products manufactured therefrom.

Shells alone, naturally, should be used as fuel in the drying kilns. At first they smoke somewhat, but they make about the best and the hottest bed of coals. Sad to relate, husks also are frequently used to help out the shell supply, which ought to be adequate if the drying kiln is properly built. Coconut shell is about the highest-grade fuel in the vegetable kingdom; for some unexplained reason it burns with little smoke and with an intense heat. If shoveled into the firebox of a steam boiler, unmixed with wood or husks, the grates soon warp and might melt if the draft were strong. The charcoal made by retorting coconut shell is excellent. Experiments in the Philippine Bureau of Science laboratories have shown that the gas produced in a retort from one coconut husk and one shell is sufficient to develop one horse-power for one hour in a gas engine. Recently a desiccated coconut factory has been installed on this plan. In the future coconut plantation machinery will be run, at extremely low cost, on husk- and shell-gas.

To have copra clean, dry, smokeless, and evenly dried, it should be dried in a dryer. There are hot-air ovens with and without forced draft, with various trays, chain belts, worm shafts, and the like, and they frequently scorch and sometimes burn the copra. There are drying-chamber systems, simple, safe, and slow. There are steam-pipe hot-air dehydrators,[1] practically trouble-proof, in which the meat is spread on perforated-bottom trays sliding into the body of the oven and over tiers of tubing in horizontal coils carrying steam under about 75 pounds pressure, which gives the optimum temperature of 150° to 180° F. and turns out a fragrant white copra in fifteen to twenty-five hours, bone dry, untainted, and without sand.

[1] In Manila in 1912 the Philippine Bureau of Agriculture exhibited such an apparatus designed by the author; several improvements have been added since that time.

An interesting point regarding the meat structure is that the outside, next to the shell, is comparatively dry with a high percentage of oil and little sugar, while the concave surface, next to the cavity, has little oil but may contain 19 per cent sugar. The kernel of a slightly immature nut has plenty of sugar but not much oil, which may in part account for a feature of the New York market: the confectioners care more, presumably, for the tender texture and sweetness than for the food (oil) value.

The kernel in an average-sized nut weighs some 25 to 35 ounces; the shell weighs about 7 to 9 ounces. The meat is about 3/5 inch thick. The cavity should hold about a pint, frequently much less, of course, and it should be about four-fifths full of the milk water. This latter liquid has around 4 per cent of sugar in solution, together with several substances which deserve careful study.

On the average plantation a combination of the sun-drying and kiln methods is recommended. The items necessary are a brick and metal drying floor built over a huge fire-box, say 15 feet wide and as long as desired, with doors every few feet for throwing in the husks and shells; a roof on rollers and a track so that it can be rolled off from over the drying floor when the sun shines and over it when it rains; a series of lattice-bottomed trays on racks or on rollers, so that they can be run out (presenting a large area to the sun) or all loosely telescoped in together over the fire-box-heated floor and under the roof when artificial heat is necessary.

In wet localities, however, it hardly pays to depend on the sun at all. A steam-pipe dryer should be installed. For the latter apparatus the initial cost is high, but the fuel and water cost practically nothing and it works as well on rainy days as clear ones. Perfectly dry husks are very fair fuel, but damp ones are poor. Husks should be stored in roofed false walls in piles 2 to 3 feet wide and as high and long as desired. Woven fence-wire or bamboo lattice-work

keeps the shape of the wall, and air blowing though the mass of husks removes the moisture.

Unfortunately most of the copra is bought by weight; consequently the maker should, of course, leave as much water in it as he dares. This gives opportunity to the always-waiting molds which lose no time in turning oil-content into spore dust. At times, however, the heat from the half-decaying cargo of half-dry copra is strong enough to destroy or check the fungi. Passengers are warned not to breathe too much of the acrid gas from the copra-hold ventilators.

Oil is not usually produced on the plantation. In the future, presumably, most of the large plantations will turn out oil. That oil will be pure, no fatty acids practically, and it will have a fresh nutty taste. There will be no copra: the nuts will be steamed to loosen the meat from the shell; the meat immediately ground fine and then treated with high-pressure steam in a large tank till every globule of oil escapes from the fiber; the oil is run off and the pulp put through a filter-press, then under the hydraulic; these free and press oils are then mixed if desirable, chilled to freeze out the water (at 72° F. pure coconut oil becomes a snow-white butter), and then sterilized, i.e., run into the steel drums very hot. An 80 per cent extraction is claimed for this process. Low-grade copra yields 55 per cent oil, good copra 65 to 70 per cent in a good mill in the old-fashioned way.

Poonac.

The cake left after pressing the ground and heated copra is excellent feed for farm animals. Most poonac still carries 3 to 4 per cent of oil, unless a chemical solvent has been used in place of the old press: in which case the cake is fertilizer or sawdust instead of cattle feed. Up to the outbreak of the World War vast quantities of copra were handled in out-of-the-way places in the Orient in small

native-run factories, hand wooden-screw presses and open cauldrons being used; and therefrom came the richest, most fragrant poonac. Then came the expeller presses, at fabulous prices: since the bulky copra could not well be shipped it had to be turned into oil locally.

Poonac has a stimulating effect on the milk-secreting and related glands of animals. Probably some undiscovered vitamin-like substance or principle is abundant in coconut meat, which must be considered aside from the high food value of the material itself.

Coconut milk.

The so-called "milk" is about 96 per cent water and from 3 to about 4 per cent sugar, depending on the degree of ripeness of the nut. In the fresh, ripe or nearly ripe nut this liquid is an excellent beverage, and thousands of barrels of it are drunk daily. However, it must not be compared with the concentrated, opalescent, or milky liquid found in the cavity of the coconut in the northern markets. The latter liquid should, of course, be saved if possible when the nut is opened in a temperate zone kitchen; it may have a tang if the nut has been kept several months, but even then it is almost certainly germ-free and nutritious.

Coconut should be brought into a northern kitchen because the freshly grated or ground meat has the best flavor, and the grated meat drenched with boiling water yields two rich materials with which every housekeeper should be familiar: a de-oiled delicious material, which when squeezed and then browned with sugar in a frying-pan or iron kettle over a slow fire makes what is known in Latin America as "polvo de amor," a unique dessert dish or breakfast food; and a real "vegetable cream," a white cream-like emulsion which carries all the flavor and exquisite aroma of the meat, and is applied to a thin custard and poured over sponge cake, the most famous coconut dish of tropical America. If tired of semi-artificial butters, one may set the oil-and-water emulsion when cool into the

refrigerator for over night, or a day, then churn it with an egg-beater.

In the Philippine Islands in the pre-copra-boom days of 1910, no less than 40,000,000 gallons (at 10 cents) of "tuba," or "toddy," sap from the cut-off end of the flower-spadix, were consumed. This sap, containing about 12 to 15 per cent sugar, is a delightful drink if it can be obtained free from flies. The Malay sets the tuba away in a cool place in large earthenware jars to ferment and, when seething strongly, distills it, making his fiery dangerous "bino" (*vino* being wine), or "arrack": re-distilled the arrack becomes alcohol for man or motor.

Coconut sugar.

Strange to say, the world knows little of the sugar which is one to seven in the sap. Palm jaggery is almost as good eating as maple-sugar, but like the latter it is at its best only when fresh-made or re-crystallized. Immediately after dropping into the bamboo-joint bucket the tuba starts fermenting. That means that some of the sugar is inverted to the molasses type and some is changed into alcohol; but worse than that, the proteid matter in solution begins to sour (liming the bamboo receptacles helps a little), aided by a hot sun. The sap for sugar-making, then, must be promptly boiled down.[1] The night flow, collected laboriously (even where the tapped trees are connected near their crowns by bamboo foot-ways, one strong stem to walk on and a light one to hold with the free hand) at daybreak, is better, *i.e.*, less soured.

The gula, as the Malays call it, is chemically sucrose, cane-sugar; but the invert-sugar, the proteid substances, and the peculiar-tasting impurities (which made maple-sugar famous) combine to make this a suspicious-appearing but delicious by-product.

For six months of the year a coconut will yield about 2 pounds of sap a day. An acre of tapped palms, therefore,

[1] See Chapter XIV.

gives 12 tons of sap in six months, which should yield some 1½ tons of sugar, one-half as much as an acre of sugar palms or sugar-cane. Of course, the tapping must be done just right, a thin shaving cut off the bleeding end of the unopened flower-bud twice a day.

Coir.

Coir (pronounced *kire*) is the general term for the sennit rope yarn, and matting bristles which, with the dust, make up the coconut husk. Either cheap labor or very good machinery is necessary for this material to compete successfully with the sisals, hemps, and piassavas. Since the old days when ship captains cherished coir hawsers, because they would stretch a bit before breaking and endure salt-water soaking for years, there have come into the market two rivals, Philippine abacá and Yucatan sisal.

A few machines have been invented. Some skutch the husks, long steel teeth on rapidly revolving cylinders comb out the dust and short fibers, leaving the stiff long fibers in the operator's hand; others beat out the worthless stuff.

Coir dust, as a sort of substitute for ground cork, has some value in linoleum manufacture. Its high content of tannin and its remarkable water-holding quality render it an ideal substance for packing seeds and fresh fruits where a certain degree of moisture must be maintained a long time, with no danger of molds or decay germs. There is a 500-ton heap of this material in Porto Rico ten years old and it has not rotted yet.

VARIETIES OF COCONUT

The number of coconut varieties has never been determined. Wester [1] records over eighty names, but thinks there may be only twelve distinct varieties in the Philippines at present. The writer [2] considers that there are between

[1] Wester, P. J., "The Coconut Palm: Its Culture and Uses," Philippine Bur. Agr. Bull. 35, 1920.

[2] Barrett, O. W., "The Philippine Coconut Industry," Philippine Bur. Agr. Bull. 25, Manila, 1913.

PLATE XV.—Young coconut with ten bunches of fruit. *Inset:* the "aerial sidewalk" for collecting coconut "tuba."

twenty and thirty really distinct sorts. Between Bombay and Bangkok there are many names; from Formosa to Tahiti there are many more, mostly in Dutch Malaya. They have never been duly collected. A botanical garden here and there may have assembled a dozen types; Madagascar has long been gathering them and probably has the largest list.

Pemba, apparently native to the island of Pemba in the Zanzibar protectorate, is a rather small-sized tree, though 45-foot specimens are known in the Zambesi Valley; husk pale but bright shining yellow, and thin; very prolific.

Ivory is a two-variety type of the Philippines and southeast Asia. The meat is decidedly below the average. The weird whitish husk renders the tree distinguishable at some distance.

Pink-husk, or Kalimbahim, has the fibrous portion of the husk a beautiful rose or pinkish shade; otherwise resembles the common Yellow.

Chocó is the very large thick-husked variety of eastern Panama and northern Colombia.

San Blas is the famous free-shelling variety from the San Blas archipelago stretching along the north coast of eastern Panama. It has a longish nut in a long angular husk. It has saved many thousand dollars to desiccated manufacturers, because its meat is inclined to come out whole from the shell, thus eliminating many motions of the parers' hands.

Green shares about equally with its twin sister the complete dominance, probably 99 per cent, of the world's plantations.

Yellow is the same as the Green, except that the petioles, spathes, and unripe husks are yellowish instead of greenish. It is debatable whether there are any connecting links between these twins, whether they come true to seed, and also whether the Green does best in wet places.

Macapunó is a sort of freak. A large (probably variable) proportion of the nuts of these Philippine trees have the

entire cavity filled with a tender sphere of meat of extra good flavor, wherefore the "dulce" maker pays cheerfully several times the ordinary price. Since these freak nuts are said never to germinate, the variety is perpetuated from the normal fruits, which can, of course, easily be picked out by giving them a shake.

The Dadeh, one of the fourteen varieties in evidence on the island of Singapore, has detached granules of the endosperm floating in the milk, and is thus a table, rather than a copra, variety.

Dwarf is a class or group of varieties (perhaps only four or five distinct) characterized by a short or slender trunk or by a small fruit, or both. Some Philippine Dahilis and Mangipuds begin bearing the third or fourth year, with the first bunches barely clearing the ground, and they appear so prolific that a movement was started a few years ago for their wholesale cultivation in Florida and neighboring countries. They are worthy denizens of the front-yard but they are short-lived. Some nuts are only 2 or 3 inches in diameter when husked.

Edible-husk, or Nawassi, a strikingly distinct type, is rare except in India and Ceylon. The husk of the immature nut is saturated with a sweetish or slightly acid sap carrying a small amount of an astringent substance.

King, or Tambili, is a famous variety of Ceylon and India. The nut is yellow, ovoid, and has an extra amount of sugar, wherefore it is more popular with cooks than copra growers. The Kuning, of Singapore, noted for its great sweetness, may be synonymous.

Needle, of the Nicobar Islands, "has a long triangular fruit, the nut tapering to a sharp point at the end," according to Macmillan.[1]

PESTS AND DISEASES

Coconuts will endure much ill treatment and are very tenacious of life; but if *Phytophthora faberi* gains entrance

[1] Macmillan, H. F., "Tropical Gardening and Planting," 1925.

into the terminal bud the doom of that tree is sealed. Four to six months afterwards the leaves, beginning with the youngest, are on the ground, rotted clear off at their base. At the first symptom of the central (vertical) leaves wilting, the tree should be felled and the bud, with its deadly fungus germs, roasted by burning a pile of dry leaves and husks on it. The oriental bud-rot is usually caused by *P. palmivora,* while the West Indian has recently been shown [1] to be due to *P. faberi,* usually accompanied by one or more bacilli or bacteria. Both these terrible fungi are now known to occur in both the Old and New World tropics. Formerly bud-rot was believed to be due to *Bacillus coli.*

Tropical America has suffered severely from bud-rot. Trinidad has lost many hundred palms, but Cuba many thousands. It now remains to be seen whether the fell-and-burn method recently put into practice by the Insular and Federal Governments in Porto Rico will check the spread of this terrible disease. In India the Malabar coast and in the Philippines a few localities have had serious outbreaks from time to time.

The dreaded stem-bleeding disease, *Thielaviopsis paradoxa,* of the Orient, is serious; the fungus enters wounds and gradually kills the tree.

Other fungous diseases [2] are widespread in the tropics of both hemispheres. Some attack the leaf and may shorten the life of it very greatly. Some attack the base of the trunk, mostly of young palms, and cut off much or even all of the sap supply. Remedies are few. One cannot very well spray coconuts over 25 feet high, and nothing can be done with an invasion of the interior tissues by mycelia or bacteria, except, sometimes, to drain, lime, and ring-ditch the affected trees. A ring-ditch, 1½ feet deep, 12 or 15 feet out from the trunk base, the earth thrown back onto the circle, may stop a fungus spreading from one tree to its companions.

[1] Tucker, C. M., Journ. Agr. Research, Vol. XXXII, No. 5, 1926.

[2] Stevenson, John A., "Foreign Plant Diseases," U. S. Dept. Agr., 1926.

Abscission[1] is one of the commonest and most serious troubles of the coconut. In all countries there is a considerable fall of very small fruits, say from 1 to 3 inches in diameter. There are two possible reasons for this physiological trouble: non-fertilization of the female flowers through weakness of the stamens or possibly of the stigmas themselves, or through failure of the pollen to reach the stigmas on account of absence of the proper insects for carrying the pollen. Where lack of insects is believed to be the cause of the sterility of the fruits, it is recommended that bees be established in or near the grove. It is difficult to prove the efficiency of bees but evidence in tropical America is decidedly in favor of the idea. When the fall of fruits is suspected to be due to weakness of the reproductive organs of the flowers, an application of some form of phosphoric acid is recommended; 5 to 15 pounds of acid phosphate applied broadcast at some distance away from the base of the trunk should give the tree greater reproductive vigor.

Another form of abscission which is really a disease is caused by some fungus or possibly bacterium entering the base of the nut and destroying the pedicel. The nuts attacked with this disease are usually from 4 inches to full size. In some plantations nearly one-half of the nuts in a certain area may drop before reaching maturity. Since these nuts contain no deposited endosperm and since the water in the shell is tainted by the action of the fungus, they cannot be used even for feeding pigs. Thus far, no remedies are known for this form of false abscission but it should be carefully studied. Quite possibly, a strong application of nitrogen with or without potash would give the tree sufficient extra vigor to enable it to resist the attack of the germs.

Scale insects weaken trees of all ages and kinds in all countries, and most of them actually poison the parenchyma for a short distance away from their beaks, just as a

[1] Carpoptosis has been proposed as the etymologically more correct name.

mosquito poisons man. Millions of dollars worth of nuts are not produced every year, because these insects drink the blood, almost literally, of coconuts.

Old "uang," the Rhinoceros beetle (*Oryctes rhinoceros*), is the foremost coconut pest. They chew the heart out of many thousands of palm-buds every season. There are some twelve species of these giant horned "June-beetles," ranging from the southern Pacific throughout the vast archipelagoes of the Orient to the mid-east Indian region. Not the grubs, strange to say, but the adult beetles dig one-inch holes into the terminal cabbage bud. The larvæ live in decaying vegetable matter, especially the dead trunks of palms, old logs, heaps of leaves, husks, or manure. Fortunately a beneficent fungus, *Metarrhizium anisopliæ,* attacks the fat white grubs. If one larva succumbs and the spores disperse well, the days of the other larvæ are numbered. In Bohol in the center of the Philippines, the natives protect the kagwang, Galeopithecus sp., a sort of flying-squirrel the size of a rabbit, and clothed with soft fur, in the belief that it eats the uang beetles.

The palm weevil, *Rhynchophorus ferrugineus,* enters anywhere in a cutlass wound or crack in the trunk. The young white footless grub goes straight into the center of the trunk, usually ten to fifty in a nest, eating out a huge cavity in the softer interior. The tree does not die at once, of course: a coconut will bear a fair crop with a hole right through the trunk. Hand-picking, at bait wounds or pieces of fresh trunk tissue, is the remedy. Palm weevils seem to be distributed all over the tropics, yet they seldom do great damage.

In the back districts of Borneo, where the mist banks slip down from the lofty peaks onto the steamy plains, coconuts are attacked by bigger pests: wild pigs and deer go for the young palms, and bruang and the orang-utan steal the nuts. Jungle pigs are so voracious in some places, like the excessively rich Agusan valley in northeastern Mindanáo, that they will leave no sprouting coconut in

its hole unless it is protected with a strong fence or a deep ditch.

Rats are one of the coconut's worst enemies. In some countries (Porto Rico, Trinidad) zinc or tin bands are nailed onto the trunk to prevent their climbing up to gnaw off the nuts; in the Philippines and Polynesia a bundle of thorny branches tied around the bole keeps down most of the rats and all the clumsy crabs.

Locusts in the Zambesi Valley, the Philippines, and rarely in northern South America periodically descend upon groves and, if they come down hungry and spend the night, half a hundredweight, perhaps, on each leaf, there is only the bare bones, the midribs, left in the morning.

CHAPTER XIII

THE OIL PALM

One of the major crops of the tropics is *Elæis guineensis.* It is old as a food-plant but very young as a plantation crop. It is said that no traveler has ever found one of these palms in a site where it might not have been planted originally by some native. Like the coconut, therefore, it is really a cultigen, no primitive wild form unchanged by man having been discovered. It has been cultivated so long that the only African species has broken up into some fifteen or twenty varieties. The other well-known species of *Elæis* is *E. melanocarpa* of the swampy coasts of northern Colombia, Panama, Costa Rica, and the lower Amazon Valley, with dwarf crooked trunk and smaller leaves and fruits.

Twenty years ago *Elæis guineensis* was hardly a cultivated crop; today there are 30,000 acres or more in grove form in Sumatra and 10,000 to 12,000 acres in the remainder of Dutch and British Malaya. Much land too poor for rubber but near the great rubber plantations is being planted with oil palm. By 1930 the export of palm oil from Sumatra alone is calculated at over 60,000 tons a year, or nearly one-third of the present African outturn.[1]

The cultivated Malayan trees yield about twice as much as the wild ones. Moreover, individual tree-yields and then the acre-yield will increase.

[1] Some eight or ten years ago one of the largest agricultural-industrial syndicates started vast plantations of oil palms in the Congo Free State where the syndicate had just been granted enormous concessions of land; while the venture has not been a fiasco, it is reported as staggering under a top-heavy load, and suffering from extravagance.

Elæis gives two crops, an edible and a semi-inedible oil. Figuratively speaking, this old "chna," as it is called in Liberia, gives down trade butter in three-quarters of her udder and milk for table use from the other; for the oil from the seed, or kernel inside the hard shell, is white and may be used in all sorts of margarines and cooking oils, while the bulkier, tallowy, red-orange grease from the fleshy pericarp is of value for many trade purposes from plating iron with tin to greasing railway-car axles, and the strong stomach of a Kru-boy can digest it fairly well when freshly made.

While well known in Europe for twenty-five years, comparatively little of the 500,000 or more tons of kernels and 200,000 tons of palm oil reaches the western hemisphere. Yet this, perhaps the most obscure of the major crops in the tropics, really affects the ebb and flow and the mean level of foodstuffs in both Europe and America: a flow of 1,300 or 1,400 tons of kernels a day into the food-oil raw-material market brings down the price of copra and cotton-seed oil and therefore of milk and butter.

There are millions on millions of semi-cultivated oil palms, standing in old "shamba" grounds, open thin forest where once native crops have been tended, scattered over more than a million square miles in Africa from Sierra Leone around all the long sweep of the Guinea Coast to Angola, back up the vast Congo Valley for hundreds of miles, up nearly to Lake Tchad and out into the boundless French Sudan. One chief may lay claim to 5,000 bearing trees, another to 50,000, and a king may have a million. There are no labor laws or danger of strikes. A multitude of old women sits beside heaps of the nuts, cracking one by one the daily 11,200,000 pounds of nuts; cracking ten nuts a minute and working six hours a day it must require 90,000 to 100,000 pairs of hands every day in the year to get out the said quota of kernels. The stronger women are out in the shambas, planting, weeding, harvesting, or else in long lines with the men, Indian file in the narrow, twisting,

sunken paths, so narrow that the white man needs a stick always in one hand to keep his balance, carrying home on their heads the rough bunches of fresh palm fruits gathered a mile away from the kraal, perhaps.

The nut is set and held in a slight depression in the old anvil of wood or stone; only just enough force must be given to crack the bony shell without crushing the kernel, for the trader will not buy broken kernels. A few portable cracking-machines have appeared.

It requires 4 bushels of nuts to yield a bushel (50 pounds) of kernels; and four days cracking to get a bushel of kernels. Before the nut goes on the store pile it must be depulped—not a very easy matter, considering the amount of tough bristly fiber in the flesh. This fresh fruit contains 32 per cent oil, but with the wasteful practices in use by the natives in Africa only about 10 per cent of the total weight is extracted as pulp-oil. The fibrous mass after boiling and squeezing with the hands still contains 25 per cent of the orange-colored tallow.

A hundred pounds of kernels yield about 10 pounds of oil by native methods and more than twice as much by modern presses. The press cake is prized in Europe for a cattle-feed ingredient. A hundred pounds of fresh ripe fruit yield rather less than 14 pounds of butter. Several tropical palms appear about equal in oil yield: the inaja, *Maximiliana regia,* has 25 per cent of buttery oil in the pericarp; the tucuma, *Astrocaryum Tucuma,* has a 37 per cent pulp and a 38 per cent kernel.

The average oil palm begins to bear when only five years old if it has not been necessary to fight weeds and brush; at that age the trunk is just taking shape, say, 3 feet high. At fifteen years the tree should be in its prime, though it keeps on growing for forty to fifty years or more, till it reaches 40 or even 60 feet. No native likes to climb a trunk over 35 feet tall; and the over-ripe fruits which finally drop out of the bunch are hardly fit for oil. The old leaf-bases cling to the trunk like those of the date; on the lower portion of

an old palm they rot and fall off, thus leaving the trunk bare below and more or less scraggly above (Plate XVI).

The peduncle is usually so short that the head of fruits sits tight in the leaf-axil, surrounded closely by the more or less spiny petioles. These heads average only some 8 pounds, though many weigh two or three times that. The stiff sharp points of the numerous bracts—one for each fruit—protrude beyond the blackish fruits and render the handling of the bunches difficult and dangerous. The central core, or shortened peduncle, tapers rapidly from a diameter of about 3 inches to a point near the apex of the conical spheroidal head. When ripe the shining fruits, with their dark reddish or brownish shadings at the irregularly tapering base, are knocked out of the bunch with a stick or pried out with a strong short knife.

Once free from the bracts, the fruits, varying in size from a cherry to a small plum, are, if the best oil is to be made for the native table, put into large iron kettles with a small amount of water. Boiling and steaming for half an hour loosens the pulp so that when the fruits are taken out and pounded in a trough or large mortar and squeezed in strong net-bags of coarse fiber, most of the reddish oil escapes and flows by gravity to the lower part of the huge trough or vat or canoe where it is dipped up, strained and set away in jars, tins, drums, anything that will hold this semi-solid tallowy oil, the "ni-chna," or water-oil, of the highest quality. The nuts, like small plump peach-pits, are removed, so far as convenient, from the fiber-pulp mass, which then is given another boiling. These nuts, about 70 per cent of the weight of the fresh fruit, are thrown on the pile for future attention. They may stay in the cracking heap for several or many months before the kernels (about 27 per cent by weight) go into the export bag, or the palm-leaf "canja" if the shipping place is far away. The shells are used for fuel, though they are not equal to coconut shells for this purpose, and there is usually a surplus dump-heap somewhere in or just outside of the village which may contain tons of old shell.

The oil obtained from the second boiling and pressing is thicker and is known as "boh-chna," or trade oil. When the crop is at its peak or whenever there is a good supply of fruits coming in, the whole village may give a few days to making up several hundredweight of boh-chna. Of course the trade stuff is made from under-ripe and over-ripe fruits, and materials other than fibers have been found in the trade canja loads.

There are many methods of loosening up the pulp from the nut in preparing the trade oil. One common way is to tread the cooked fruits in trenches or pits, say 2 feet deep in hard clay. Free fatty acids develop rapidly in the fruits after ripening and also during the delays in the various processes between beating the fruits out of the head and molding the cooled pasty oil into shape for taking down to the factory. The sour rancid oils bring lower prices than those made up quickly from fresh fruits.

The lowest grade of oil is the "sô-chna," or stone oil. This is made from over-ripe fruits picked up under trees (too tall, perhaps, for safe climbing), from heads that will not shell easily, or from regular heads. These are dumped into a large pit, say 10 to 15 feet across; then hot stones are thrown into the mass and palm leaves and some earth are put on top. After three to five days, this fermenting mass is dug out of the pit and worked up—boiling, squeezing, straining. It is not clean enough for "palm chop," but good enough for tin-plate mills.

The average West African oil palm tree produces only about five bunches a year, the total weight of fruit being only about 40 pounds a year. From this the native averages only some 3¼ to 3½ pounds of oil and some 28 pounds of nuts which he may crack, if trade is good, and get 7 or 8 pounds of kernels. Good trees, of course, will yield several times as much as this, but in the wild many fine large trees seldom produce a single bunch.

A few years after the commercial success of palm oil and kernels in the vegetable oil manufacturing centers of Hamburg, Marseilles, and Liverpool, planters both in the Orient

and also even in Brazil and Mozambique began to plant Elæis. In Buitenzorg, Java, a half acre or more were set out in coconut style in the Experiment Station plats and these old trees (about 40 feet high in 1918) have behaved very well, though not in an ideal site. In Brazil hundreds of acres of these palms have been bearing better than would be expected in their semi-neglected condition. In Mozambique it became necessary to advise against the planting of Elæis in valuable land which was needed for maize and provisions.

Some fourteen years ago Sumatra began planting, mostly in soils too poor for rubber, on properties owned by the large companies. These palms grew and yielded so well that the Elæis boom expanded over into British Malaya, Java, and other islands. The outturn of these young Elæis in Malayan groves is about double that of the wild African palms.[1]

About 60 palms are set to the acre; 70 or 80 can stand but Elæis seems to resent crowding rather more than does Cocos.

In ordinary conditions about $40 brings an acre into bearing: clearing, planting, and cleaning for five years. The first five years of cropping should bring in a gross return of $75 to $125 an acre, mostly for the pulp oil. The kernels are larger and more easily extracted from the larger bunches borne by the fully mature palms. Around $175 or even more may be expected for the oil from an acre of palms twelve to twenty-five years old, and $50 to $75 for the kernels. No one knows yet how long an Elæis grove can be kept profitably; probably the economic life of the cultivated oil palm is under sixty years, somewhat less than the coconut. The palms in the prosperous young Sumatran plantations are visited about every five days. On account of the uneven ripening of the fruits in the bunch, one of its

[1] Within a decade it is estimated the production of palm oil and kernels in the Dutch Malayan plantations will exceed the West African output.

greatest faults, some of the fruits may drop out or at least start that dreaded oxidation process which forms free fatty acids in the pulp oil.

Soon after the War a large vegetable oil syndicate erected palm oil extraction plants in the Belgian Congo. With new types of machinery these factories got 80 per cent extraction of the pericarp and 90 per cent in the nearly fiber-free and fresh kernels. Sumatran mills, however, were not satisfied with the Congo methods and began experimenting. Now they are obtaining nearly 100 per cent of the pulp oil. Two processes, about equally efficient, are now in use: one digests the whole fruit in closed steam tanks, then centrifuges it; the other removes the pericarp first, allowing, if so desired, the expression of a raw cold process oil, and giving an uncooked kernel.

Several years ago the steamers plying on the Congo River began using palm oil in the semi-Diesel type of engine. This heavy non-volatile oil possessed certain advantages over the costly and evanescent gasoline. Recent tests show that palm oil can be fractioned rather easily, using zinc chloride as the catalyzer; 1,000 kilos of oil yields 630 kilos of petrol and 98 kilos of glycerine; and these 630 kilos fractioned into 15 per cent naphtha-like fluid, 25 per cent illuminating oil, and 60 per cent of a heavy petrol.

There is a hopeful future for this industry, when an acre of poor soil can turn out 2,500 pounds of palm oil, which gives over 200 gallons of motor spirit and enough glycerine and kernels to pay all the upkeep and operation. The shells—about a ton to the acre a year—may be retorted, like coconut shells, and the gas from this waste material would run the engines of the factory.

PESTS AND DISEASES

In its native home Elæis appears to have very few troubles, aside from the destructive fires which the natives set whenever the country becomes very dry. These destroy most of the young volunteer seedlings and sometimes full-

size palms are injured by the fire smoldering up their trunks in the ragged mass of old leaf-bases.

The uang, or common Rhinoceros beetle, *Oryctes rhinoceros* of the coconut, attacks the oil palm in Malaya, burrowing down into the terminal bud. Trunk-boring weevils, Rhynchophorus spp., also infest some Malayan plantations; there are three dangerous species. The coconut case-worm, Mahasena sp., is reported as injuring young palms in the Orient.

Occasionally a bud-rot attacks old Elæis trees and a brown-rot may destroy young ones.

A species of Marasmius is often found on old leaf-bases and fruit-heads. The leaves seem to be remarkably free from rusts and blights.

OUTLOOK FOR THE OIL PALM

It is claimed that one-half of the West African crop is never turned into trade channels. The amount of oil and kernels could be increased by 50 per cent and still leave plenty of fruit for the natives' needs—no small item when over 40,000,000 people are more or less affected by this palm. The domestic consumption in Nigeria is estimated at 100,000 tons a year.[1]

Roads are building back into districts practically untouched; where the sweating Kru used to stagger along under his sixty-pound "canja" filled with kernels or "bohchna" for three or four days, now the one-ton truck comes down in one day with twenty man-loads. Narrow-gauge railways will cut across arid sand wastes and swamps. Launches would be more popular on the rivers but for the

[1] The Nigerian oil palm stands are the best. Although in West Calabar, one of the main districts for this industry, the labor and transport difficulties "allow only about 10 per cent of the available fruit to be gathered," the total exports of the oil from the Colony now amount to around 120,000 tons a year, about 100 per cent increase in the past quarter century; and besides the oil there is an export item of 250,000 tons (50 ship-loads) of the kernels, an increase of over 127 per cent over the 1900 figure.

PLATE XVI.—The oil palm (*Elæis guineensis*) in Trinidad, showing bunches of fruit.

fact that Glossina flies dart out from the shady bank thickets at any passing object.

Leaf pruning and pollination may give good results.

This palm is, like many other species, monœcious; the pollen from a male inflorescence on one tree may produce larger or better fruits on another. Hand pollination, in a crude way, is already a Malayan field practice.

For future oil palm cultivation in West Africa the filling-in crop system is recommended. A fairly good stand of the wild palms in various stages of growth, with a good lay of the land for roads or Decauville track to carry the raw product to the factory or shipping point, is cleared out, only valuable timber trees being left, and the palms when too thick are thinned; then the one-, two-, or three-year-old volunteer seedlings from vigorous heavy-yielding trees are carefully dug up during the rainy season and transplanted into the open spaces, 20 to 25 feet apart, till the entire area is filled in solid. This method will give a constant outturn, gradually increasing; considerable time and expense is saved; the lack of row regularity is a minor defect.

In the Orient, however, regulation seed selection, nursery practice, and methodical spacing in the field will continue. Africa has many hundreds of thousands of acres where the filling in system can be operated with the minimum expense and delay in bringing in the full outturn from the concession or leased tract. Malaya, and Brazil, also, have a thousand acres here and there whereon Elæis can be grown very successfully. Selection, breeding up, variety tests on one hand and steadily improving factory methods on the other will eventuate in a rise in this newly cultivated old oil palm, the source of the beautiful firm fat and one of the finest food-oil kernels known.[1]

[1] United States imports of palm oil in calendar year 1926 amounted to over 65,000 tons, worth over $10,000,000. Of palm kernel oil some 37,000 tons, worth $7,086,702, were imported during the same period; and there were also some raw kernels not separately listed.

CHAPTER XIV

OTHER PALM PRODUCTS

THE average economist can hardly credit the fact that palms produce about 1,000,000,000 pounds of sugar a year —three-fourths of a pound per capita. Yet for many years India has been consuming over 400,000 tons of this delicious "gur," made from four species of palms, and only a rather small portion of the total number is ever tapped. The author has been criticized for stating that the world's palms could, if tapped properly, produce more sugar than all the other sugar-yielding crops combined. The following rough estimates of the world's stands of sugar palms may appear incredible but are probably much too conservative:

The 500,000,000 coconuts, tapping only two spadices, should yield 50 pounds of sugar (a pint of 16-per-cent sap a day on the average) each, or 12,500,000 tons.

The African wine palm, Raphia spp., occupies, it is reported, some 5,000 square miles of the coastal swamps of the Gold Coast, and there is probably twice as much area besides from the Cameroons around to Sierra Leone. However, half that total, or 5,000,000 acres, would have 40 palms to the acre, in some stands 100, or 200,000,000 trees which should produce much more than 50 pounds each, or a total of 5,000,000 tons.

There are, according to Macmillan, some 125,000 acres of the Palmyra palm, *Borassus flabellifer,* in Ceylon and India. These stands are close, about 100 trees to the acre; at 80 pounds of gur (50 to 100 gallons of sap) each, the yield would be 500,000 tons.

In India, mostly in the Madras region, there are some 60,000 acres of the wild date (*Phœnix sylvestris*) under a

sort of cultivation. Macmillan states that these stands yield "as much as 9 tons of jaggery per acre," say 500,000 tons.

Only an estimate can be made of the number of oil palms in West Africa between the Middle Congo and Sierra Leone. If Liberia has, as the author estimated in 1920, some 30,000,000 to 40,000,000, trees, there should be eight or ten times as many in the ten other countries, say 300,000,000 trees. The 3,000,000 cultivated trees in Malaya are not counted in. At 35 pounds a tree the total sugar output would be 5,000,000 tons.

The swampy coast-lines of Borneo, the Malay Peninsula, and the Philippine Islands are a vast stand of nipah palms (*Nipa fruticans*), the only species that can endure sea-water. These almost trunkless palms easily run 300 to the acre. In the Philippines they yield about 50 pounds of sugar for an acre each day for six months, or 9,000 pounds a year; therefore, the 2,000,000 or more acres would yield 9,000,000 tons.

The beautiful kitul, wine, or toddy palm, *Caryota urens*, indigenous to the whole far-flung region from west-central India to the middle of the East Indies, is one of the best sugar-producers. Macmillan states that a single tree "is capable of giving an annual yield of 180 gallons" of toddy, say 1,400 pounds of sap or nearly 200 pounds of sugar; there are probably not more than 5,000,000 tappable trees in the whole area, but even that makes 500,000 tons.

The buri, *Corypha elata*, occurs throughout the Philippines and is fairly common in some parts of Malaya and India. In one province of the Philippines, Pampanga, there are over 9,000,000 of these huge palms in one solid stand and there are at least as many in the remainder of the Archipelago and as many outside. Taking merely 5,000,000 of the 30,000,000 buris, at 200 pounds of sugar each, the yield is 1,000,000,000 pounds or 500,000 tons.

From Morocco to central India there are, according to Paul Popenoe, 90,000,000 date palms; they are frequently

tapped for toddy and arrack when too old for fruiting. If they yielded at the same rate as the inferior wild date of India, 100 pounds of sugar to a tree, the product would be 4,500,000 tons.

There are many million palm trees (Attalea, Euterpe, Orbignya, Mauritia, Maximiliana, Astrocaryum), in the Orinoco and Amazon basins and in Central America, which could be tapped. No sugar is made there now, although some of the natives prepare an exceedingly intoxicating liquor by fermenting the sap of certain species. At the very least 60,000,000 large specimens could yield over 50 pounds each, or 1,500,000 tons.

The true sugar palm, or kaong or areng, *Arenga saccharifera,* grows wild, or rarely semi-cultivated from Java and the Malay Peninsula up through the Philippines and Siam to Indo-China, where there are vast areas filled with it. There are probably over 50,000,000 palms there, and each one can give a pound of sugar a day during most of the year; say 150 pounds each, or 3,750,000 tons.

These ten or twenty palms, therefore, could produce over 43,000,000 tons or nearly twice as much as the sugar-cane and sugar-beet combined. Also at the end of the year the palms are, with the exception of the buris, just as good as they were at the beginning, and practically nothing has been spent for cultivation or fertilizers.

Experiments made in Cavite Province in Luzon, Philippine Islands, in 1913 indicated that the sugar palm, *Arenga saccharifera,* would yield about the same amount of sugar to the acre as sugar-cane. The tapping, collection, and transportation of the sap are not expensive. Weed shrubs are cutlassed once or twice a year, and the paths to the trees are kept open. By the current old method the fresh sap, 15 to 17 per cent sucrose, is boiled in open kettles till the dark colored but very delicious massecuite forms. In the same year C. W. Hines and the author accidentally discovered a process for making a very light instead of a very dark colored sugar from kaong, Arenga, sap. By first pre-

cipitating the albumen-like substances and then removing the gummy resins and acids from the filtered liquid, a nearly pure solution of sucrose was obtained which could rapidly be boiled down to the crystallization point without danger of discoloring the end product.

All of the rich palm saps can be clarified by this double-precipitation process. The dark massecuite, made in open kettles in the jungle, however, may be run into palm-leaf baskets—as is done in India—or molds, and these are sent to the refinery. It is the foreign substances or impurities which give the exquisite flavor of these gurs or jaggeries, as well as the panelas (tropical American sugar-cane massecuites) and maple-sugar.

Besides the continuous tapping method—the gradual paring off, day after day, of the distal end of the unopened flower-bud (spathe and spadix first beaten then tied up, then cut)—there is often practiced on large palm species which flower only once a destructive tapping method. Just before the huge inflorescence is ready to burst forth from the center of the terminal bud, a deep horizontal channel is cut into the trunk near the top. The sweet sap, ready for the many thousands of flowers, rushes out of this channel into large containers at an amazing rate. More than a barrel of sirupy sap may be collected in one day, but, of course, the tree bleeds to death in about a week, after giving from 200 to 250 pounds of sugar.

In Central America certain palms are felled and a large boat-shaped cavity is chopped out of the upper side of the trunk near the leaves. This cavity fills, several times a day, with the sap which, of course, immediately begins to ferment, so that after the first day the contents of the sap reservoir are highly charged with alcohol, vinegar, and many flavory substances—not to mention the insects.

SAGO

Most of the sugar-producing palms also yield sago. The kitul and the kaong, when too old for profitable tapping,

may be felled, split, and the fibrous interior pounded to loosen the starch-grains, which are removed with little washing; 200 pounds of a more or less astringent "sagu" may be taken from a fifteen-foot trunk. Supposing that there should be a regular planted acre of sugar palms: the sago from 5 per cent of the trees should sell for enough to pay all the up-keep expenses and maintain the sugar orchard in fine condition indefinitely. About 60 trees out of the 100 in the acre should be producing constantly. One laborer could take care of an acre. Each tree should yield a pound of sugar a day while flowing, 7 pounds of 16-per-cent sap. Paying the field man half a dollar and allowing 30 cents for the boiling, there would be a net profit of $1.00 an acre a day, allowing only 3 cents a pound for the sugar.

Sago is theoretically about the cheapest agricultural, or rather forestry, product in the whole range of food crops. A sago swamp is good forever; it constantly renews itself; there is no cultivation except the thinning-out of surplus suckers around the parent clumps.

Metroxylon Sagu is a medium-sized palm, 10 to 15 feet high, which grows in fresh-water swamps or very wet ground; there are several forms, some with terrible thorns, some smooth. Just before the inflorescence appears, at the age of about a dozen years, the trunk is cut into lengths convenient for carrying to the factory. Split, pounded, and washed repeatedly, these trunk sections release their starch, from one to two hundredweight a trunk. At $3.00 a cwt., and cutting only one-twelfth of the 200 or more trees in the acre each year (25 cwt.), it is obvious that the sagu would be profitable.

By the time the main trunk is ripe there are from two to four side shoots of various ages coming from near the base of the often procumbent stem. As with bananas, these suckers, if expertly managed, will give mature trunks when desired.

The viable seed is seldom or never seen, though flowers are often produced.

It is strange that no one has ever taken up this industry

which should easily be one of much profit and interest. The vast reaches of the sagu swamp in the almost unexplored Agusan Valley of northeastern Mindanao could starch-feed the whole island: 25 cwt. to the acre, and 50,000 acres, over 5 ounces each a day for 1,000,000 people.

Probably this same sagu, in proper hands, could be developed into a first-class sugar-yielding palm; it would only be necessary to find how to tap it.

In 1912 there was a very serious drought in the Philippine Islands; crops could not even be planted; food supplies ran out. The natives went into the nearest "bosque," selected a mature buri, *Corypha elata*, or kaong, Arenga, felled it, pounded up the starchy pith and took out enough sago to last the neighborhood a week.

VEGETABLE IVORY

Tagua, or vegetable ivory, is derived from species of Phytelephas. For many years these denizens of Colombian and Ecuadorian swamps and wet low forests were supposed to be all the same species; the old genus has recently been broken up into many species. Until long after maturity these raphia-like plants have no trunk, but since they live very long a fairly tall stem may develop. Probably all species are diœcious.

The huge "negro-head" cluster of six or seven adhering fruits each with half a dozen large seeds may weigh 50 pounds or more. When "in the milk" these nuts contain a very nutritious jelly which the natives use in making a combination food-drink. Gradually this albumen, the endosperm, hardens till it really seems like ivory; this hardest albumen known can be cut only with special saws. It takes dyes and polishes well. The nut kernels vary much in shape and size, 1½ to 3½ inches in diameter.

The business of button manufacture from tagua was for a long time largely confined to a small district in Germany. It was for many years about a $10,000,000 industry; tagua now has to compete with many cheap imitations.

Ecuador alone used to export some 20,000 tons of tagua,

Colombia less; the Canal Zone is about its northern limit. Fifty thousand tons are the normal output. The United States takes over half since the War. It has wrongly been called "corozo-nut."

The price of rubber affects the amount of tagua collected; the jungle folk prefer the hard life of the "seringeiro" (or "ulero" if he works in the Castilla region) to the easier work of driving burro-trains down from the tagua forests. Thus the demand for rubber rather directly affects the supply of ivory buttons.

The majestic *Attalea funifera* of Brazil furnishes "coquilla nuts," used as a substitute for tagua. Likewise the very hard seeds in twelve-foot racemes of the still larger African wine palm, *Raphia vinifera,* can be used in button work. A beautiful palm, *Metroxylon vitiense,* with large red scaly fruits of the western Pacific has been planted out in groves for button raw material. The talipot, *Corypha umbraculifera,* yields large bony seeds, very inferior, however, to tagua.

PALMS YIELDING OIL

Growing somewhat like the great raphias of Africa, the attaleas of tropical America are crop plants of great potential value. In many regions of Nicaragua, Colombia, and Brazil they form vast stands and vie with the coconut and the oil palm as large producers of oil; in fact the cohune of Central America yields not only the bland white kernel oil for edible foodstuffs but also a thick pericarp tallow resembling that of the Elæis species of Africa.

The cohune, *Attalea Cohune,* came into prominence during the Great War. Its nutshells, with or without the kernels, were an excellent substitute for coconut shells for the special sort of charcoal used in the gas masks.

British Honduras is reported to have nearly 2,000,000 acres (40 per cent of the total area) in wild cohune. Each of these palms bears two to four huge bunches of nuts each year, say 200 pounds; with only forty palms, this gives 4

tons to the acre or 8,000,000 tons for that small country. Nicaragua could easily treble that. The pulp is 10 to 15 per cent yellowish fat, or 3,000,000 tons. The kernels, some 10 per cent of the husked nut, contain over 60 per cent oil, or 1,000,000 tons. The yearly yield is $750,000,000 of these two oils, twice the value of coconuts and oil palms combined, and practically every bit of it is wasted. With launches on the rivers and lagoons and narrow truck roads into the heaviest stands, a half of this little known but great future crop could be brought out into trade routes.

Cattle swallow the fruits whole. The oily pulp digests off, leaving the shell smooth.

The vast reaches of the Amazon and Orinoco basins contain untold millions of oil palms of some twenty species, several of which are apparently better and more worthy of cultivation than the Elæis. Like the African palm, most of these American species yield two oils, one from the pericarp and one from the kernel.

The inaja, *Maximiliana regia,* has good-sized fruits in enormous clusters, the pulp containing 25 per cent of an orange-yellow oil, while the kernels are like those of Elæis.

The babassú, *Orbignya speciosa,* and the curua-una, *O. monosperma,* are immense palms occurring in very extensive stands on the ground just above the swamps. From time to time lots of babassú nuts are shipped to Germany or United States. In 1922 some 26,000 tons were exported. This nut, about the size of a small pointed apple, has two or three kernels but they are difficult to extract. The oil is apparently as wholesome as coconut oil.

The curua-piranga, *Attalea spectabilis,* is even better than babassú and is widely distributed. There are probably several varieties, some fruits containing two or three, others up to five or six kernels. One of these fruits yields two or three times as much oil as a babassú. All the attaleas would endure cultivation.

The corozo, or mucaja, *Acrocomia sclerocarpa,* is probably the most widely distributed palm in tropical America;

from Mexico to southern Brazil this very spiny palm is common. It was perhaps the only edible oil, except that from sea turtles, known to the Arawak Amerinds in the Antilles. The hollow endosperm dried contains 55 per cent of a water-white edible oil. Just before ripening the hard pericarp also carries 27 per cent of another heavier edible oil.

Both the tucuma, *Astrocaryum Tucuma,* and the murumuru, *A. Murumuru,* are very abundant in the lower Amazon Valley, and it is strange that these palms have not yet been exploited. The latter species has a kernel representing 45 per cent of the weight of the dry nut, and 35 to 40 per cent of the kernel is edible oil and fat. The tucuma pulp yields 37 per cent of its weight in an edible oil, while the kernels give about 38 per cent of good quality oil. Another species, the jauary, *A. Jauary,* has similar fruits and grows in the varzeas. There are ten other palms in that valley which produce, like Elæis, both pulp- and kernel-oils of value for human consumption.

The pejibaye or peach palm, *Guilielma utilis,* has great possibilities as a food plant. This very thorny palm extends from lower Mexico to northern Brazil. It stands 20 to 40 feet high. The reddish fruits are borne in clusters, and have a dryish, mealy, sweet pericarp surrounding the seed. Boiled, not raw, this squash-like pulp is very nutritious and can be used in a variety of dishes.

The doum, or gingerbread, palm, *Hyphæne thebaica,* of Egypt has pulp comparable to that of the pejibaye. It is one of the very few palm species which normally branches. It is very common in Nubia and the eastern Sudan. The mealy fibrous pericarp is an important food there.

THE DATE PALM

The date, *Phœnix dactylifera,* is one of the oldest crops. Its original habitat cannot be determined; Egypt, Arabia, and India can with equal reason claim to be its cradle. Wild species of Phœnix are scattered from Morocco to

Mozambique and over about half of Asia; but a real wild date has not been discovered.

The industry of the date, the rival of the oil palm for second place in economic importance, is growing in two directions: the old plantations in south Persia, eastern Arabia, and some parts of northern Africa and northwestern India are extending to meet the increased demand in America and Europe; and in California and Arizona a very good beginning in the scientific cultivation of the best varieties of this fruit has been made.

The major portion of the date crop is still consumed locally, but there are now some 50,000 tons in international trade. The demand for the higher-grade varieties is increasing and the price seems to be going up. Twenty-five years ago the old Fardh could be retailed at 8 cents a pound; the Deglet Noor now brings $1.00.

Like sugar and cotton, the tropical date may become widely grown outside the tropics. It is predicted that within fifteen years date culture will be the leading horticultural industry of Arizona. The Coachella Valley in California is now producing upwards of 1,000,000 pounds a year and at such a profit that suckers for planting are now selling at $20.00 whereas in 1913-15 some 15,000 offshoots were distributed to planters at $2.78.

This 50- to 75-foot palm can perhaps resist more drought and grow with less rain (5 to 15 inches) than any other crop. In fact, it does not succeed well except under desert conditions. In the humid tropics a fungus (*Graphiola phœnicis*) seriously attacks the leaflets; yet a tree in Port-au-Prince, Haiti, carries crops of fully 200 pounds.

Propagation is now almost entirely by the offshoots which sprout from the base of the trunk from five to fifteen years old. Seedlings are being tried, but the waiting period of five to six years is tedious and the fruit of most seedling trees is almost inedible. An exception to this rule occurred in 1907; a tree in Key West, grown from a Fardh seed presumably, bore excellent fruits of a theretofore unknown

type, the fruit being exceedingly long and slender, with the flavor of coconut and spice.

One male tree to about fifty females is the practice in modern orchards. Pollen may be taken in vials from one grove to another and dusted onto female inflorescences. Absolutely dry weather is necessary during the pollination period as well as during the maturation of the fruit.

Processes to control and hasten the full ripening of the fruits are being studied. Properly managed artificial ripening (twenty to sixty days) improves the flavor of the fruit over that ripened on the tree. High temperatures seem advantageous.

Chemically there are two types of dates, those with cane-sugar (the drys) and those with invert-sugar. The sucrose-content of the cured fruit is about 70 per cent—one of the sweetest fruits of the world. The fat-content is 2.5 per cent and the proteids run nearly 2 per cent. Varietal variation is great.

At 75 to 100 years the tree stops fruiting; it should then be tapped to death. The toddy may be drunk fresh or fermented and distilled into arrack; in cuneiform inscriptions date toddy was called "the drink of life." Sugar could, of course, be made by tapping any date that does not fruit well. Shallow incisions are made in the trunk near the top bud, though, of course, the inflorescence bud could be tapped as well. An exceedingly strong drink is distilled from cull dates.

The yield varies greatly, from less than a hundredweight to six times as much. A mature cultivated tree ought to give over 250 pounds a year. The first crop should come the sixth year. Fifty to 60 trees to the acre, and $1.00 a pound for the fruit, give the grower a gross return of some $15,000 a year. The date will in the future rival the grapefruit as the most profitable crop in the tropics.

Although dates had been harvested in Arizona as early as 1865, no regular introduction was made till 1889-90 when the United States Department of Agriculture success-

PLATE XVII.—Six-year-old Deglet Noor date palm, bearing over 100 pounds of fruit, as grown in western hemisphere.

fully shipped rooted suckers in tubs from Egypt to California. About four-fifths of the imported suckers were lost, usually, between the mother palms and the live grove. The separation of the suckers from the trunk and their forced rooting (in tents) are delicate operations, the technique of which has recently been worked out.

There are some 90,000,000 date palms. About half this number, according to the date authority, Paul Popenoe, are grown around the Persian Gulf. The Bagdad region has the greatest number [1] of good varieties. No other fruit has so many named varieties; the number runs into thousands and there are not many synonyms. However, there are only some twenty-five varieties in trade.

The Mesopotamian Halawi and Khadhrawi are at present the most popular varieties of dates in the American market. The Fardh is scientifically cultivated in the Samail Valley of Oman in southeastern Arabia and extensively shipped all over the world, a cheap, dark, wet fruit. The Khalaseh, Deglet Noor (Plate XVII), and Maktum are perhaps the best dessert varieties.

The Mexican tableland appears to be a very auspicious region for date cultivation, so far as climate and soil go; if all else were favorable this district could supply the world.

[1] Popenoe, Wilson, "Manual of Tropical and Subtropical Fruits," 1920.

CHAPTER XV

RUBBER

Rubber is one of the youngest of the world's major crops, being just about 100 years old. Only about one-half this period, however, has there been any real cultivated rubber on the market and most of the great plantations of the Far East are less than twenty-five years old. Coffee has been grown by civilized planters since 1700, tea for several centuries, and rice, maize, sugar-cane and coconuts are lost in the dim purlieus of ancient history. Cinchona is the only similar case of rapid domestication and commercialization of a wild tree species. Rubber now vies with coffee as the second most important export crop of the tropics; reckoning the average price a pound at 50 cents, the 660,000 tons or more now in trade amount to much more than the total export value of coffee. Whether the public will suffer a severe shortage of this raw material in the next two years is a problem.

For some years rubber has been in the lime-light more, perhaps, than any other crop ever has been. The press relishes the taste of the word, the general public pretends a keen interest in the trade status; the average citizen has a fairly clear conception of the source and knows something of its manufacture; in one country, it is said there are 22,000,000 owners of vehicles which run on rubber tires and four times as many others who use some form of rubber in routine ways and means.

Whether caoutchouc was first discovered in South or Central America will never be known. Some 1,300 years ago there appeared in Central America a race known as the Olmecas, neighbors or forerunners of the Toltecs and

Mayas. They not only made bouncing lumps of it for a sacred game, but they modeled figures in it, water-proofed fabrics and used it as an incense, supposedly potent for producing rain.

Wilcox [1] records the finding of a mass of rubber not less than 300 years old in an olla in the ruins of an Amerind pueblo in Arizona, and the center of the mass was still elastic.

The early Spanish explorers noticed the "Indianos" playing with balls of a strange new substance. Years afterward someone made the great discovery that pieces of this unique elastic gum would rub out pencil marks; thereupon it was called "India-rubber." The Portuguese name is borracha and seringa is merely the name of the hevea tree in its native habitat. Jebe (pronounced nearly like heavy), the Amazonian name, is correct. Caoutchouc, presumably a French combination of caucho and cahucha, the up-river names, is the technical appellation. The most sensible name is the Dutch gomelastiek. Chemically rubber is a gum, produced commercially by eighty species of trees, shrubs, vines and a few herbs.

Hardly any other crop is economically so nearly indispensable to the modern world. Artificial rubber may come, or at least a substitute or adulterant which may severely upset the present status.

Just previous to the great 1910 boom, the world production of rubber was only some 70,000 tons. About 50 per cent of this total came from tropical American forests, about one-third from Africa, and most of the remainder from south Asia. The insignificant 3,000 tons of cultivated rubber was produced mostly in the original plantations in Ceylon and Malaya (Johore and Straits Settlements). The rapid increase of the plantation output from the 3,000 tons of 1909 to the 400,000 tons of 1918 is one of the marvels of tropical agriculture; the 65 per cent increase in the following period of the same length is not so surprising.

[1] Wilcox, E. V., "Tropical Agriculture," 1924.

The first commercial shipment of rubber was made from Pará in 1827—about 40 tons. By 1853 a small lot (4 tons) came down the great river from Peru, and in that first boom year some 2,600 tons entered the world's markets. The discovery of vulcanization about that time gave a great impetus to the industry and tapping "estradas" were opened up over quite a stretch of territory. Bolivia began shipping about 1865, Venezuela in 1866 and Colombia in 1869.

In 1876 Henry A. Wickham was a small planter some 500 miles up the Amazon River, when he received a request, from the India Office in London, for 70,000 hevea seeds. These seeds, it appears, were collected on the low (about 300 feet) plateau just west of Boim near the juncture of the Tapajoz with the Amazonas at Santarem. At that time the Brazilian authorities guarded the export of everything connected with the government "borracho" monopoly; but Wickham (now Sir Henry) succeeded in getting his seeds, billed as botanical specimens for Queen Victoria, out of Pará and rushed them over to Kew Gardens where they were planted just in time to obtain a few seedlings. As soon as they were large enough to endure the journey, these young heveas were sent to the botanical gardens of Peradeniya (Ceylon) and Singapore. Seed from these trees was distributed in the eighties, and before 1900 the question of seed supply gave no more trouble; their descendants by the million now fill the immense plantations in the Malay Peninsula, Sumatra, Java, and Borneo.

Over the two million or more acres of cultivated rubber the cost of production has fallen rather rapidly since 1918, from around 23 to 27 cents a pound down to some 14 to 18 cents, not counting the vast array of native growers whose time is cheap.

Up through the Amazon Valley there is almost unlimited rubber forest but such a shortage of labor in most districts and so few ways of transportation that only some 20,000 tons comes out unless the price stays high. The estimated 300,000,000 tappable wild hevea trees in the Amazon Basin

could, if all gave a low yield of 7 pounds a tree, produce nearly twice as much rubber as the world now uses.

PLANTS THAT YIELD RUBBER

About 90 per cent of the world's rubber is produced by species of Hevea; and probably 90 per cent of the hevea rubber is from *H. brasiliensis* and *H. Benthamiana.* This genus is typical of the Euphorbiaceæ; it is confined to equatorial America and comprises about seventeen species. *H. guianensis* grows entirely on the north side of the Amazon, while the two other mentioned species are mostly confined to the south side. These produce the true "jebe" rubbers (Plates XVIII, XIX).

Castilloa is a genus of the Moraceæ, comprising several species of "ule" trees. They extend from central Mexico down into Peru. Their rubber is known as "caucho."

Manihot, also of the Euphorbia family, is a rather large genus of tropical America. The best known species is *M. Glaziovii,* the old Ceará rubber of eastern and northern Brazil. Other species of the dry regions of Brazil are *M. dichotoma* or Jequié rubber, *M. piauhyensis* or Remano rubber, *M. heptaphylla.* These three latter species are all known as Manicoba rubbers. Ceará was the first rubber to be planted commercially. It has seldom "paid its keep," however, in Ceylon, where it was introduced in 1877, India, East Africa, or Java.

Silk rubber, or lagos, is produced by two or three species of Funtumia or Kickxia, native to tropical Africa. For some reason the Funtumias do not grow well outside of Africa, and few plantations have been set out there. It is a very disappointing tree with a high-grade gum.

Rambong, or Assam, rubber is produced by *Ficus elastica,* the well-known ornamental plant. The rubber is low grade but at one time it was boomed and quite large areas in Java, especially, were set out at great expense.

Jelutong is a third-class caoutchouc produced throughout Malaya by various species of Dyera and Alstonia of the

Apocynaceæ. The rubber is very poor and full of resin, but the flow of latex is astounding, not equaled, probably, by any other plants in the world. From 1910 to 1915 it was boomed. The very abundant latex of the jelutongs is now coming to extensive use in place of chicle in the manufacture of chewing gum.

The guayule is an insignificant-looking shrub of the desert of northern Mexico and the adjacent districts of the United States. Fortunes have been lost and some made with this composite weed (*Parthenium argentatum*) which contains no latex, but has granules of a caoutchouc-like substance scattered through its woody tissues. It grows 2 to 4 feet high and takes ten to twenty years to mature, it is reported. It is the only non-tropical rubber to be exploited.

The Landolphias (half a dozen species or more) are very interesting lianas of the African jungles, some attaining a length of 300 feet and a diameter of a foot or so. They produce beautiful flowers and some species bear edible fruits. The latex coagulates promptly and is wound up into balls, usually by pulling the strips off the wounds and rolling them up one after the other, bark and all.

There are several shrubs in both East and West Africa which have coarse woody tuberous roots containing considerable low-grade caoutchouc. Carpodinus was once quite important. A stemless member of the Milkweed family, *Raphionacme utilis,* in East Central Africa has turnip-like roots whose rubber is extracted by slicing and boiling. Clitandra (of the Apocynaceæ) from the same region is a vine-producing rubber both above and below ground.

Madagascar, as would be expected, has its own special kinds of rubbers: The "lombiri," one of the beautiful Cryptostegias, and the "hazondrano" *Mascarenhasia elastica,* both of the Apocynaceæ, are the best known. The latter is one of the few swamp rubber trees.

Indo-China and Siam have numerous giant lianas and

trees of the Apocynaceæ and Moraceæ, but they have not been investigated.

Scattered through the veld thickets of Mozambique is a weird leafless tree, *Euphorbia rhipsaloides,* called "almeidina." Its intensely sticky latex makes a firm water-proof paint for ships' hulls.

Colombia and Venezuela have several "caucho" and "cow" trees. "Virgen" and "Esmeralda" gomas, in the Spanish idiom, are the product of two Sapiums. One of the large "cows," *Brosimum utile,* gives quite a well-flavored rich milk.

The Dogbane family (Apocynaceæ) seems to hold the most species which produce true caoutchouc; the Euphorbiaceæ come second; Moraceæ, third; and Asclepiadaceæ fourth. Neither of the two great tropical families, Leguminosæ and Rubiaceæ, seems to possess elastic gum.

CHEMISTRY OF RUBBER

Perhaps about no other similar raw product is there so much doubt, chemically speaking, as rubber. After thirty or more years of technical study the subject is still little understood. It is not known whether caoutchouc protects the plant or prevents wound infection, a popular theory but not very sound. Some species of a genus have rubber, others closely related do not. It probably does not act as a food reserve. It may be distantly related to some of the resins, but it is certainly not any kind of starch, sugar or oil, the standard food reserve substances in nearly all plants. Many substances have been called colloids, but not rubber.

It can easily be said that rubber is a gum-like hydrocarbon, a terpene or isoprene, having the formula C_5H_8, but it is not so easily classified. The molecule is certainly a "multiple," unsaturated; it is quick to grasp any suitable element, such as sulfur, iodine, bromine, and chlorine. When all the molecules in a caoutchouc mass have linked themselves up with all the sulfur molecules they can grasp, past

the vulcanizing stage, the result is the caoutchouc-sulfur amalgam known as ebonite.

India rubber in the bark of a tree is a yellowish watery liquid; the numerous globules floating about in the colorless or greenish or yellowish sap give the emulsion a white or nearly white color, just as the yellow globules of butter suspended in the pale greenish casein-water, or whey liquid, make the emulsion of mammal milk appear white. Brought together by any of the many means into a mass, the liquid droplets solidify into a substance which is nearly white at first, turning a dull grayish or greenish-yellow and finally to a peculiar brownish-bistre shade as its water-content goes down from 15 per cent or more when first rolled to 2 per cent or less after hanging for a few weeks in the curing room. Commercial rubber, of course, may be black, like the hevea latex smoked in built-up balls over palm-nut fires, or the blocks of castilloa full of rotten proteid stuffs and smelling like an unclean stable, or reddish, like some of the vine rubbers, or almost any color except blue or green.

To say that the caoutchouc globules polymerize does not facilitate an understanding as to how the liquid freezes instantly into the solid—the most elastic of solids, to be sure, but certainly not a liquid. When milk cream is churned the fat globules are amassed but not polymerized: the fat is just the same all the way from that mysterious glandular layer which takes in blood on one side and passes out water, casein, sugar, and fat on the other, to the glomerated semi-solid butter of the churn. Rubber, however, is not so simple.

Theoretically, caoutchouc, like the other hydrocarbons and the carbohydrates, should be elaborated in the leaf parenchyma; but, a much better flow is obtained at the base of the trunk and a better, stronger rubber than from the top of the tree. Both hevea and ceará flow about as well at the end of their leafless period as when the trees are in full leaf. Between the corky layer outside and the

cambium next to the wood, there is a complex set of tissues, two or three blended layers, and running more or less longitudinally, branching, anastosmosing together are the laticiferous tubules. Hevea bark is nearly or quite half an inch thick on a medium-sized (1½ to 2½ feet diameter) tree. The sap and the latex are under pressure, but it is a question why milk should flow freely from a cut in hevea bark when the same cut in the bark of a hundred other similar-looking neighboring trees causes little or no flow of even a watery sap. Other problems are: why the lower side of the tapping scarf when scraped oozes three times as much latex as the upper side an inch or so above and why the leaf-laboratories do not push and gravity pull it downward?

If the purpose, the formation and the flow of latex are little understood, its coagulation is even more puzzling. A simple case may be taken: here are quart bowls of caucho (castilloa) latex, all the same; into one is stirred a spoonful of acetic acid or vinegar and in one minute a beautiful twelve-ounce biscuit of white caoutchouc floats in the nasty-looking sap; into the next bowl a spoonful of ammonia is stirred, with the same result exactly; an ounce or so of bejuco juice poured into the third causes the same result; a dozen or so large Atta ants (with their formic acid fangs) mashed up and stirred in No. 4 bowl does the same; a generous pinch of pulverized mangrove bark in No. 5 gives identical results; cigar smoke blown through a glass tube into No. 6 and the biscuit is promptly made; the contents of No. 7 are diluted with clear water and centrifuged in a cream separator or any gravity-multiplying machine, then the creamy stuff is churned or whipped with a little water, and the same biscuit results; No. 8 is set aside over night, letting the enzymes and maybe bacteria ferment the sap liquid, and in the morning a few taps on the side of the bowl or a few flips with the spoon or ladle and coagulation ensues; but if a dozen drops of formaldehyde are put in bowl No. 9 the latex stays as it is for any reasonable length of time, even if shaken about; this is quite an important

commercial fact, for it makes it possible to ship latex from Sumatra to New York in drums.

When blood clots it is known that a fibrin net is formed somehow, enmeshing the corpuscles; and when rennet extract or certain acids are added to warm milk a casein web draws together, catching the fat globules, if any are left. However, something else happens when caoutchouc coagulates and, to date, one can only guess what it is: no use to talk of colloids, nor proteid webs. The coagulum is its own web and the globules must fuse, in some unexplained manner, into a sponge-like mass whose vacuoles practically disappear under pressure and evaporation.

CULTIVATION OF RUBBER

A few years ago the wild product was superior in bulk if not in quality to the cultivated crop; now the tame rubber is twelve or fifteen times greater than the wild. The rise of rubber as a cultivated crop has been paralleled, perhaps, in a small way by vanilla and cinchona. Several misfit rubber species are still in evidence in grove form, as Castilloa, Ceará and Assam (Ficus), in Africa a few odd acres of Funtumia and in Brazil a little Mangabeira; but 94 per cent or so of cultivated rubber is Pará (Hevea species).

Sites and soils.

Hevea was believed to be a varzea, or flood-plain, tree. Naturally, the most convenient trees for tapping were those on or near the banks of the many navigable rivers. There were no roads. Dug-out canoes, rafts, and launches were the only vehicles used in transporting rubber. However, behind the varzeas were the real stands of seringa, or jebe. Old seringueiros, who have roamed about the hinterland and the almost unknown lands of the vast Matto Grosso country of central Brazil, asseverate the existence of almost unlimited quantities of big hevea trees on high ground, even on rocky hills far from any wet land.

The fact that hevea prefers well-drained ground is of

great importance. A site protected from strong winds and not troubled with long droughts is suitable anywhere in the tropics. The temperature should be reasonably high, an annual mean of 70° to 85°, or higher if the humidity is not too great. Hevea endures 51°, but probably better enjoys 102°, the maximum Amazon temperature. Some believe a short dry season is good to give the tree a chance to ripen off and shed its leaves.

Many heveas are planted in sandy soil, but do not thrive in light loose sand. Some clays, on the other hand, are too heavy. Hevea should be planted where the growth of the virgin forest is good.

Seedlings.

The seed should come from trees of superior performance. A dab of blue paint may mark these progenitors. Children collect the fresh seeds two or three times a week in the long fruiting season. This is not easy if the tree is tall, since the exploding seed-capsule hurls the three beautiful mottled-brown seeds for five or ten yards.

The bamboo pot is perhaps the safest method of handling these valuable seedlings. They have one fault, as the smaller diameters, under 2 inches, may cramp the root development of the young trees. The seedlings should not be kept more than a few months in bamboo. The good points of bamboo pots are extreme cheapness, lightness and non-breakableness. When wetted and taken to the field holes, the pot is thrust down into the loose earth of the partly filled hole, then one side of the half-rotted pot is split off with two strokes of a short knife or a hatchet, then the earth is firmed about the plant, which has not been shocked by having its roots broken, and hence loses no time in starting to grow in its permanent site.

The seed-bed is easier to manage than pots. On a raised bed of rich sifted soil, containing no rotten wood nor even dead leaves, the seeds are sown broadcast or laid along in rows, 6 by 12 inches apart and then covered with half an

inch of sandy loam well pressed down. About 90 per cent of the seeds should be showing growth in three weeks.

When the seedlings have formed six leaves or so they may be lifted over into the nursery, all weak spindling plants, say 10 per cent of the total, being discarded. Rows in the nursery should be far enough apart to permit a laborer to walk between them when weeding, and at least a foot or even two apart in the row, depending somewhat on how long the trees are to be kept there. Now they can be fed up, heavily fertilized with liquid manure or chemical nitrates.

It frequently happens that hevea seedlings have to be left a year or so in the propagation rows. They should be root-pruned, however, if they reach a height of 6 feet or more, so that the shock of transplanting will be lessened. The tops also may be lopped off if it becomes necessary to hold the trees a long time in the nursery rows.

Some shade is advised for the seedlings up to the second year; they need morning and afternoon sun and always plenty of air, without wind whipping. If no large trees are available, a half-shade roof, about five feet above the ground can be made with a few palm leaves laid on wires nailed onto any sort of posts. Many seed-beds are made out in the open, but the sun in the dry season is likely to overheat and crack the soil surface and the leaves seem to get too much evaporation strain.

Planting and care.

The plantation site should be gone over carefully, not only by an experienced topographer who lays out the roads, if any, the drains, the terracing perhaps, and the windbelts if necessary, but also by a mycologist. Probably no other crop is so sensitive to subterranean fungous attacks as hevea. If a healthy young seedling is planted ten feet away from an old stump in process of decay, probably some of the white or reddish mycelial threads will, within a year, find the hevea roots and rot them. These facultative fungi,

such as the much dreaded Fomes, common everywhere in the tropics, and Poria, live on either dead or living tissues and they take a heavy toll in nearly all plantations started on newly cleared land. Prevention is the only way of avoiding losses: stumps must be burned, blasted or dug out. Ordinarily there is not much difficulty in exposing the main roots and burning them in position, but in the case of large dadaps (Erythrina species) full of a sap which dries out only when the wood is split into small pieces, it may cost twenty or more days labor to remove even the main surface roots. If the superintendent finds traces of the vampire-like rhizomorphs of the root parasites in the hole prepared for the seedling, he may order the hole to be enlarged and held open a few months to "sweeten up." Fomes threads do not like the taste of chemical fertilizers; even a shovelful of ashes wards off an attack for a year.

The holes may be anywhere from 15 to 30 feet apart, and about 3 feet in diameter by 2 to 3 feet deep, depending on the size of the seedlings, quality of soil and subsoil. A hundred trees to the acre is a good number to begin with, 20 by 20 feet; later a 20 to 30 per cent reduction should be made.

The young trees are set out in fairly good forest soil—recently cleared jungle—with a good content of fixed nitrogen bound up in its humus. Exposing this surface soil to sun and air brings about the transformation of this nitrogen into nitrites and nitrates which, being readily soluble, are rapidly leached out and drained away down-hill, the young trees getting a taste of them during the first two or three years. Then the period of semi-sterility begins. The interspaces are probably kept clean, no fresh nitrogen is fixed anew and little is left for the soil organisms to work up into the available forms for the roots to drink in. The sun beats down on the unprotected soil, heating it up to 120° F. or even (if black) to 130° F., killing the beneficial aerobic bacteria, if they have not already starved to death through lack of humus; the subsoil is hopelessly tight and

practically sterile. This deplorable state of affairs continues until the rubber trees shade the ground and blanket it somewhat with their fallen leaves. This slack period is costly, for every factor which retards the development of a hevea tree, potentially worth $25 or more, is a financial item not to be ignored.

Besides the nitrogen losses, there are calcium troubles due to the popular clean-cultivation system. The heavy tropical rains falling on the unblanketed ground and flowing too fast over and through the surface soil carry away most of the soluble lime compounds. Some sort of blanket must be kept over the root area as long as there is any danger of sun-heat; and the interspace should have some cover always. For young heveas there is nothing better than the cowpea; and for the interspaces the many forms and species of velvet bean, Lyon bean, or any of the low-growing legume vines are recommended. Wherever the king cobra is known to exist, only those cover-crops forming mats close to the ground should be used. If the vines get too thick, a moderate slashing will reduce the depth and help keep the soil surface supplied with plant-food. The tall-growing tephrosias and crotalarias may be planted where there is no cobra.

Aeration is almost always neglected. The method of letting air into the soil is described in Chapter V. The vertical forking method, devised by the writer in Trinidad in 1907, breaks no roots, lets air down where the soil organisms are needing it, and gets food to them also, the surface wash gradually filling the vertical holes with particles of semi-decayed material, which otherwise would probably be carried away. Silt pockets, however, at intervals along the course of the surface rivulets, help to hold some of the escaping humus. Terracing is also worth trying: On sloping ground each tree should have its own small table, slightly lower on the up-hill side; and all surface flows should be zigzagged to slow down the run-off. Subsoils usually do more harm than good when loosened and brought

up on top of the active soil; for damming small water courses, however, the heavier and solider the earth, the better.

In some cases jungle trash may be brought from the surrounding forest to be spread as manure about the young heveas; in decay these leaves and branches will help out a humus deficiency, and being on top of the soil and light there is little or no danger from the Fomes root fungi.

Pruning is seldom advisable in a hevea plantation. Every leaf and branch helps to give the tree more power.

Accessory crops are now being considered as economic adjuncts. Many rubber estates comprise large tracts in which no hevea is or should be planted; and therein two world-staple crops are now being demonstrated, usually with fair profits, oil palms and sisal. The Elæis trees yield well enough when set out on the higher ground in dryer thinner soil than that required for hevea. Even where the rainfall is much higher than would be ordinarily considered the optimum for agaves, the outturn of first-class fiber is surprisingly good. These two old crops, of very recent introduction in Malaya, are undoubtedly going to relieve much of the worry of shareholders in the companies that bought up large tracts of poor land in with their more valued portions.

Grafting.

A beginning has been made in the buddage of hevea seedlings; the last two years have seen frantic haste on some Far Eastern estates. Several thousand acres are budded and a few trees are beginning to produce. It is tedious work and not cheap, but the principle is correct and it will probably become common. Sprig-buds, such as are used by experienced mango budders, are safest, ¾ to 1½ inches, from ready-to-flush branch cions. Shield-buds and slit-buds, like those used in orange propagation, may be put in. However, seed selection is so much simpler that it will be practiced on all but the very advanced plantations. Bud-

dage may be done at any time while the diameter of the seedling stem is sizable, ¼ to ¾ inch.

Results depend on, (1) the bud from the cion tree, (2) the vigor of the stock's root system, and (3) the harmony or degree of compatibility between cion and stock.

Bearing trees may be cut back and the stump sprouts budded when of proper size, nine to twelve months. Nursery stock, ten to twenty months old, is preferred; only the vigorous seedlings are selected. Rows should be at least a foot apart, and the trees 9 to 12 inches in the row. Buds may be put in in the nursery rows or after the nursery stock plants are established in the field.

Only proved consistently high yielders should be used for bud supply. Large branches are lopped or pruned off, and two or three of the adventitious water-sprouts, which usually soon spring just below the cut, are allowed to grow for bud production. Only a trained eye and hand can determine the age and type of bud which will give best results. Sections of branches bearing mature buds should be taken to the nursery or field rolled up in wet gunny with chopped grass, wet moss, or leaves to prevent drying out. By dipping the ends of these sections (6 to 12 inches long) in paraffin, or some wax or tallow, they may be sent, if properly packed, long distances by mail or express.

A citrus budding knife, preferably with a bone spatula at the butt, is recommended.

Patch-buds are generally used, though sprigs (from branch tips) should give as good results. For the similar avocado stock, recent tests show that the sprig is much safer than the patch. A small mold or pattern block preferably with a handle attached to its center, held against the stock facilitates cutting out the square patch; and a complementary mold, open at the center, may be used for cutting the bud. Care must be taken not to injure or soil the cambium of either the bud or the stock. The stock patch, by cutting on only three sides, may be left attached above or below, the flap thus serving to protect the bud.

PLATE XVIII.—Large hevea rubber nursery at Singálong Plant Propagation Station, Manila, P. I.

Grafting tape, of the usual sort—2 parts resin, 1 part beeswax, and 1 part (or less in dry hot weather) tallow for the filler or adhesive,—is wound around the stock and over the top and bottom of the bud. It probably is immaterial, as in the case of citrus, whether the bud is set right end up. The bud should just comfortably fill the cavity of the removed patch. The few drops of oozing latex may be smeared around over the wound edges.

If both stock and bud (or cion) were in good condition, and if neither too much rain nor too much sun or drying wind interfered, the bud pcint should show signs of life in twelve to fifteen days. As soon as growth starts the stock may be lopped or cut quite off about 1 inch above the bud, and the wound painted over thoroughly to avoid checking and infections. Adventitious sprouts must be removed. The lower the bud is set, the less the danger of stock sprouts interfering with the bud shoot.

Theoretically a whole acre, say 100 trees, may be planted up with the progeny of one high-yield mother tree, each individual forever afterward behaving just like the parent; but unfortunately this does not always work out in practice.

A point to be remembered in selecting trees for buds or seeds is that the red-bark type appears to have a little better wound response and enjoys deep rich soils better, giving therein heavier yields of latex than the white-cortex type. Brown-bast, however, is not so readily detected in the red hevea.

R. A. Taylor, Physiological Botanist, Rubber Research Scheme, of Ceylon, states: [1] "It has now been proved that, while many mother trees reproduce their high-yielding properties in their budded offspring, there are some which do not; and, unless a tree has been previously tested, there is no definite assurance that the offspring so raised will come up to expectation. Unfortunately the only method, known at present, of testing this ability to hand on high-yielding

[1] Trop. Agriculturist, Aug., 1926.

properties, is actually to tap and record the yields of the progeny. This testing alone therefore requires 6 years at the very least."

Rubber budding tools are being invented. Molds for quickly cutting around the bud and for removing the same-sized piece of bark from the stock are already in use.

The very low setting of the bud—only some 2 inches above the soil surface—makes the budder's work difficult.

TAPPING THE TREES

When the capsules form and explode, the tapper may begin the blood-letting work. He starts in at daylight, since the best flow is obtained between 5:00 and 10:00 A.M. Many systems of tapping are in use, and several have been abandoned, but the basic principle is to get as much latex as possible with as little injury to the bark and as little weakening of the tree's vitality as necessary.

A common system is known as the "half-herringbone." A cut (or two or more) sloping downward just enough so that the latex will flow in the cut, is made around about half of the tree's circumference, and at the lower end of the cut a metal, porcelain, or glass cup is fastened to catch the 1 to 3 ounces (or more, of course, on large and high-yielding trees) of the cream-like white latex. Usually on the second day after the first cut a thin shaving, about 1/32 of an inch, is sliced from the lower edge of the cut, and this may be repeated every two or three days till the scarf of the cuts is 2 inches wide; then a new set of cuts is begun on the opposite side of the tree.

Tapping is begun low down on the trunk, each subsequent area of cuts being made a foot higher than the previous one on the same side. Men can reach to about six feet, the women tappers a little less; above six feet ladders are necessary.

After six months or so the tapped areas may be re-tapped if the wounds have healed well with no fungus or brown-bast symptoms. A very interesting discovery was made in

1899 in the Ceylon Botanic Gardens by Willis and Parkin. They found that the thin new bark formed over the tapping scar gave a stronger flow than the normal bark. By re-tapping, at intervals of about a week, the same area, the latex flow was more than double at the third tapping in a fortnight and was nearly eight times greater, according to Willis,[1] at each tapping after ten weeks. Wound response is noticed as indicating the vigor of the tree rather than as a practicable basis for increasing the acre outturn.

Tapping may continue throughout the year, but during leaf-fall time, usually the longer dry period, the trees are granted a few weeks rest on the best plantations. The wetter the weather, the heavier is the tapping usually; on dry days the latex tends to clot in the cut, thus forming scrap rubber. To prevent the latex from coagulating and sticking on the sides of the cup a few drops of a formaldehyde solution may be dashed into it when it is affixed to the lip of the cut.

A tapper can make 1,000 to 1,500 cuts a day, depending partly on whether there are two, three, or four cuts to a tree.

The number of tapping tools is legion, and still new ones are being invented. From the crude old machadinho, or short-bladed hatchet, with which the wild heveas are attacked in the Amazon Valley, is a long way to some of the complicated modern shaves and chisels with set-gauge wings to prevent the cutting of the cambium. For continuously good results a simple light thin-edged tool is best in the hands of a skilled Tamil, Javan, or Malayan (either male or female) laborer; the sense of touch in the fingers becomes, after a year's experience, very acute, and the dexterity of expert Tamil tappers is extremely interesting to watch. After long practice some tappers develop an almost uncanny sense of judging just when to begin and when to stop cutting and where on a certain tree. They

[1] Willis, J. C., "Agriculture in the Tropics," 1922.

can, also, pick out the good and bad producers in a grove by looking at them; and, more important still, they detect the faintest symptoms of weakening in a tree and thus can usually avoid much of the wound maladies, brown-bast troubles, and over-tapping sequels which make the grove superintendent's task very worrisome.

If all boles were smooth, the tappers' task would be far easier. The wounds heal over smoothly sometimes. Scar tissue is difficult and delicate to manage. To avoid cutting the deep gash in the bark, various pricking wheels, or spurs, have been tried for years, but seem to be in disfavor, partly because the latex cannot flow in a groove toward the cup.

The flow lasts about half an hour. Then the tapper or, if he has a large block of trees in charge, his assistant begins collecting the latex. A good-sized white-enameled bucket receives the contributions of the 200 to 400 cups. The cups may be left at the tree several days, but they soon get dirty.

In general one laborer must be allotted to every four or five acres; a 1,000-acre plantation requires fully 200 pairs of hands in the field, mostly for tapping. The wage in Malaya runs between 40 and 50 cents a day on most estates.

The science of latex manipulation is becoming very complicated, and several score of keen investigators are studying the specific problems and devising new ways and means of avoiding losses and improving qualities.

As soon as the pail, with its creamy almost snow-white "milk," smelling faintly like some drug, reaches the factory it is strained through fine wire (brass or copper, of course) cloth, to remove all particles of bark, and then is mixed with other pailfuls in a large porcelain-lined vat. The coagulum specialist then measures out so many pounds or gallons and adds thereto so much acetic acid or similar agent. In due time, say an hour, the coagulum, or clot, sponge of caoutchouc forms in the vat, the white mass of new-born rubber separating out of the greenish-brown

watery liquor which with its rich content of proteids is run reeking away into the drain ditch.

The beautiful irregular-shaped masses of the coagulum are now fed evenly into the cylinder jaws of the crêping machine, coming out as an endless ribbon of wrinkly virgin rubber, about 8 or 10 inches wide and about ⅛ inch thick. This crêped ribbon now goes to the curing house, where for several days it hangs festooned from sticks in an atmosphere of smoke, creosote and raw rubber smells: no bacterium or fungus would venture there to attack the strips.

When thoroughly dry (less than 3 per cent as against the wild rubber balls from Brazil which while fresh contain around 15 per cent moisture), these bistre-colored strips are taken down and packed, more or less tightly, into the shipping crates, 100 to 300 pounds to a box.

A new method of much promise is being tried. Instead of coagulating, the pure washed and filtered latex is sprayed, forced through fine apertures into a hot dry room where it falls as a water-free smoke-free powder, the purest form of rubber. This process is practically the same as that used in making powdered milk.

The liquid latex as a merchantable commodity has several advantages over solid caoutchouc and, were it not for the high cost of transportation, the chemical control could easily be managed. Much remains to be done in rubber technology.

YIELD OF RUBBER TREES

At five or six years the average hevea should yield 5 to 10 ounces of rubber. At ten years it ought to produce 2 or 3 pounds; at fifteen to twenty-five years the yield may be anywhere from 4 to 10 pounds. The average annual outturn from an acre of mature trees in Malaya is probably under 350 pounds, or between 4 and 5 pounds to a tree. Native planters having a few acres of closely planted trees on rather poor soil tend to over-tap their trees somewhat but they do turn out a tremendous amount of rubber. For

example, in Brunei, western Borneo, it is reported that 50 per cent of the hevea trees are owned by natives. These native small planters are usually very independent, well-to-do Chinese and Malay landowners, who resent any restrictive measures, such as the famous Stevenson Act of the British government which is supposed to hold down the production quota to 60 per cent of the quasi-normal 1920 quantity. This yield may be slightly increased in the near future by correct agronomic methods.

One acre of bearing rubber should yield from 300 pounds upward of dried seeds, reckoning 90 trees to the acre and about 400 seeds to a tree.

One long ton of the kernels may be obtained from about 427,000 air-dried seeds.

About 267,000 fresh seeds weigh one long ton. A thousand seeds weigh about 8 pounds 6 ounces. The kernels therefrom weigh 5 pounds 4 ounces and the shells 3 pounds 2 ounces. Therefore 63 per cent of the seed is kernel and 37 per cent shell, as compared with cottonseed which has 46 per cent shell and castor seeds 26 per cent shell.

The seed contains from 23 to 32 per cent of oil; the kernel itself runs from 46 to 53 per cent oil. In comparison, sesame yields about 55 per cent oil, the peanut around 50 and linseed 30 per cent. Hevea seed oil compares with linseed oil but has about one-third less "drying-power."

The cake from the presses (from kernels only) has about 8.75 per cent moisture; crude proteins 30 per cent; oil 8.7 to 11 per cent; fiber 5 per cent; ash 5.6 per cent; starch 42 per cent. The food units of this cake are 139 as against 133 for linseed cake. Cyanogenetic glucosides are estimated at 0.02 hydrocyanic acid. The cake seems to be more wholesome (except for sheep) than linseed cake; for dairy purposes up to 14 pounds a day may be fed safely, it is reported.

DISEASES AND PESTS OF RUBBER TREES

Of the 150 or more species of fungi reported as parasitic on living tissues of Pará rubber, at least fifty attack the

leaf, about the same number the bark, twenty or more the root system, and fifteen or more the fruits and flowers. The diseases of castilloa and manihot have not yet been studied.

There are also several physiological troubles, one (brown-bast) very severe in some hevea plantations.

It is a question whether the root-fungi cause greater damages than the leaf-attacking species.

Scores of thousands of dollars have been spent in grubbing out stumps and tree roots in making new clearings for hevea groves in the Orient, to avoid the subterranean attacks of the rapidly destructive mycelia of *Fomes lamaoensis* and *F. lignosus*. Both these root-rots are not only practically cosmopolitan but nearly omnivorous. These devastating root-fungi are theoretically present, like some of the terrible Fusariums, in every rich moist soil. Since they can hardly even be checked by either steam sterilization or chemical disinfection, the source of infection, dead wood, must be removed so far as practicable.

There are several nursery wilts which are usually amenable to the common sprays. Soil sterilization is recommended when conditions—humidity and high humus-content—might favor fungi.

In Brazil the tar-spot disease, caused by *Catacauma huberi*, and the so-called "South American leaf disease," caused by *Dothidella ulei*, are severe menaces to the hevea industry. While the latter disease does not appear seriously to affect the wild trees, it has caused severe losses in four countries besides Brazil. Until some control method is found, it looks very dubious for the rubber planter in this part of the world.

In the Orient two diseases cause a heavy leaf fall. The very common patch canker, *Phytophthora faberi*, of cacao and coconuts not only attacks the leaves in all stages but also the fruits and young shoots and it may even girdle the trunk. *P. meadii*, similar to the preceding species, brings about great losses in latex from Ceylon to the Malayas. Bordeaux sprays may save some young trees but can hardly be applied to trees over 35 feet high.

Brown-bast is very serious in the Far East. It is not a true disease, but a physiological disturbance which appears to be entirely or very largely due to wrong or excessive tapping. Unless the scales, warts and nodules of the affected cortex crack or peel enough to present a raw surface, no germs are found in any reddish spot or brownish streak or area in any part of the bark. Rands, after studying this bast-bark trouble for years in Java, stated that it appeared to be "an accentuated condition of gum secretion." Little or no latex flows from the brown-bast areas. Starting from a tapping scar, the brown layers and streaks may extend upward or downward, or possibly a little sidewise, to quite a number of inches or even feet, practically ruining that part of the trunk for rubber production. Nothing can be done, of course, except to rest the tree and in bad cases to scrape away the warty growths. If and when it recovers and good thick new cortex has grown over the disturbed areas, tapping may be resumed. Fortunately brown-bast has been found on old tapped heveas in the Brazilian jungle but never on the untapped trees. This naturally refutes the old idea as to the contagiousness or infectiousness. Nearly all the hevea trees of the Orient appear to be descended from the white-cortex form of Brazilian trees growing in the flooded regions of the Amazon Basin. The least trace of brown-bast in that form shows up strongly, whereas it could hardly be detected in the black- or red-cortex forms occurring much more commonly up on the higher land.

Many root-rots attack the large tap-root of hevea and, without evidencing a single symptom above ground, reduce it to a powdery mass in a comparatively few months. Many of these fungi are not yet identified; their fruiting bodies and spores seldom or never appear. Some are facultative parasites: they may live peacefully as saprophytes for a year on an old dead tree root, then break forth as parasites, devouring rapidly the main roots of healthy heveas. They are very bad but, on the whole, the planter has a greater

dread of the blights whose spores may be blown from one estate to another in a minute.

Thus far few members of the animal kingdom seriously affect the cost of producing rubber. Few mammalia even in Sumatra and the Malay States attack the trees once they are well started; wild pigs and elephants sometimes uproot the young trees. Ceará roots are starchy and probably taste like those of the near relative cassava.

Root-grubs in new plantations may be destructive; wood-ashes, salt, or chemical fertilizers dispel them.

Scale insects are always to be dreaded on both young and old trees. Kerosene emulsion, applied late in the afternoon in dry weather, is efficacious.

Locusts can defoliate a young grove, but they are to be feared only where large tracts of lallang grass are left as breeding grounds.

The latex present in all parts of the hevea plant is a good insect deterrent.

CHAPTER XVI

OTHER TREE PRODUCTS

In the tropical forests and velds of both hemispheres are several hundred different commercial products. There are as many more which are not yet sufficiently known really to enter the world's markets, of recognized value as oils, fibers, drugs, and the like. Central Brazil has the vast reaches of the Matto Grosso almost untouched. The interior of Dutch Papua has finally been reached by a party of European scientists, and has been found very rich in new fruits, crop plants, and forest products. In the northern half of the Congo Valley there are hundreds of square miles scarcely ever penetrated by white men.

Tropical forestry is hardly established yet on a solid basis, but holds a fund of interest and potential wealth-giving factors hardly comprehended by the average individual. A good beginning has been made in the Philippine Islands, where some 2,500 species of woody plants have been listed. The state of Pará is known to have 1,000 kinds of trees. The Federated Malay States are laying the foundation (technical research) at Kuala Lumpur for a great group of forest industries. Investigational work proceeds slowly; there is a great lack of funds and trained men. Venezuela is making an effort to fathom the depths of her great forests.

CINCHONA BARK

Cinchona established a record for speed in domesticating a forest tree species which rubber has not beaten. In seventeen years, from 1870 to 1887, the plantation output in

Ceylon rose from a few hundredweight to 8,000 tons of dry bark.

Discovered, or rather discussed, in 1639 in Peru, calisaya or cinchona bark gradually came into use in Europe as a remedy for malaria. Until about 1880 the forests of Colombia, Ecuador, Peru, and Bolivia furnished most of the bark in trade; but the supply was uncertain and the six or more kinds—yellow, red, brown, and the like—were confusing. Therefore, the British and Dutch governments determined to domesticate the trees. Then followed a series of attempts at smuggling the seeds and live plants out of South America into the Orient. The half romantic, half tragic history of these finally successful efforts is one of the most thrilling chapters of agricultural development.

Out of some forty species of Cinchona, only four have succeeded in the plantations of Java, India, Ceylon, and Madagascar. Recently the expert Dutch horticulturists have made several hybrids which give great promise. *C. Ledgeriana* and *C. succirubra,* the Yellow Bark and Red Bark quinine trees, are the main source of the world's supply of quinine. Formerly the bark had to be shipped in bales half way round the world to the factories. Now a large proportion of the finished product—quinine sulfate, muriate, tannate—is manufactured at or near the plantations, both in India and Java.

In the South American forests the trees, 15 to 50 feet high, were felled and the bark was stripped and hacked off crudely, a tree yielding anywhere from 10 to 30 pounds of dry bark. The plantation practices now in use in Java are as follows: branch pruning, suckering, and trunk shaving; the sucker, or sapling, system, like that excellent method for producing long "quills" of cinnamon, is the best for young plantations. Older trees endure removal of the bark in vertical strips. The bare surfaces are sometimes covered with moss to hasten cicatrization. The new bark formed under these wounds is much richer in the alkaloids than normal bark. The percentage of quinine in wild bark

remains around 7 while that of the best cultivated trees runs up to 15. Bark from the roots is also rich in the alkaloid. As with hevea, there is great individual variation, and the Dutch planters have selected, tested, selected again, breeding up more profitable pedigreed strains.

Colombia has never attracted much attention in quinine circles, but it is now projected that pack-trails and truck roads should be opened up into the cinchona forests whence, it is estimated, no less than 6,000,000 pounds of dried mature bark can be taken out annually.

GUTTA-PERCHA AND BALATA

Balata and gutta-percha are the non-elastic rubbers. Little is heard of them outside of very limited circles, yet they are practically indispensable in the world's work. No other material can safely replace these guttas in submarine cable construction; they resist the action of salt water extremely well; they are exceedingly moldable when hot and they hold the impression with just the right amount of flexibility. They are worth several million dollars a year.

The bully or bullet-wood, *Mimusops Balata,* is one of the most majestic trees of Trinidad and northern South America, some old specimens attaining a diameter of 6 feet and a height of 100 or more. The abiutana, Lucuma sp., tree of the Amazon Valley has great possibilities.

Both the destructive and conservative systems of extraction are practiced. By the felling method a three-foot tree may yield 50 to 100 pounds of dry balata, especially if the bark is pressed. However, the sensible tapping method, employed in the Guianas, gives a good flow of creamy latex two or three times a year. The balata latex is fully half gum. A tapper makes a series of deep cuts one above the other as high as he can reach; the latex flows down into a nest of wild plantain leaves, a clay pocket, or a container of some type; later the partly coagulated gum is collected and then cleaned by boiling in kettles of water,

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then molding into slabs or cakes of one to two inches thickness.

If carefully managed a bully may last many years, then it may be felled for timber or charcoal. The wood is of a peculiar purplish shade.

Balata is used largely in the manufacture of machine beltings; it grips tight and never stretches. About 575 tons are imported by the United States annually.

The oriental guttas, or gatehs, are a medley lot. At least a dozen species of Palaquium—also, like Mimusops, of the Sapotaceæ—in the Malayas and the Philippine Islands, are sources of this gum. Laws regulating the tapping of gutta trees have been passed, but the Philippine Moro, the Bornean Dyak, and the Malayan rank and file of looters are not interested in white men's laws. They want weight even if they have to put a few stones and some clay into the lumps of "gateh," so they fell and get what they can of the gushing latex. It has been said that no two blocks of gutta-percha are alike; and this is not very surprising since several species of trees may have contributed to each lump and the tapping, coagulating, boiling, and drying are variable factors. In some localities rational tapping is practiced.

The Dutch discovered some years ago that the leaves of Palaquium species contain gutta. Ground and treated with chemical solvents, a hundredweight of fresh leaves may yield 10 pounds of clean pure gutta-percha. Experimental plats have been in evidence at the Buitenzorg Station for many years.

Gutta-percha, therefore, is a cultivated crop, though its culture will probably not extend rapidly. Balata is wild, and will stay so.

United States imports some 1,750 tons of gutta-percha annually.

Jelutong was mentioned in Chapter XV as the discredited source of a low-grade rubber. Recently it has come into notice again as a source of an ingredient of chewing-gum.

If the whitish or grayish chicle-like blocks can be taken apart, the 10 per cent of rubber, the large percentage of various resins, and the moderate amount of gutta-like substance, each being separated economically, the huge Dyera monarchs of the Malayan forests will be profitable. Some 7,500 tons of jelutong or pontianak (Bornean shipping port) rubber enters the United States every year.

CHICLE

Chicle is the gutta-like gum in the latex of *Sapota Achras.* The tree is the sapodilla, or naseberry, indigenous from eastern Mexico to Brazil, 20 to 40 feet high. There may be several botanical forms; there are at least three forms of the fruits, one in Panama being the size of an apple.

The thick latex contains from 25 to 50 per cent chicle; when running from the bark it is one of the most tenacious liquids.

The tapping of the zapote, or sapota, is crudely done, usually with the machete. The zigzag gashes are made 30 feet or more up the trunk, as in the case of balata, the cuts arranged so that the latex runs in a vertical stream down to the base of the bole. Instead of furnishing a receptacle for catching this flow, it is usually allowed to collect in a hollow in the earth or on a bunch of leaves; this explains why minute particles of sand are frequently noticed in the chewing-gum.

In Quintana Roo, Campeche, and Yucatan, in southeastern Mexico, however, the chiclero works more carefully, collecting the latex in canvas sacks or bolsas. He also rests his trees from four to seven years between the severe tappings, and even then about 15 per cent die from the treatment.

The flow lasts about two hours, and it may be anywhere from 1 to 60 quarts: the individual variation among the trees is amazing, some 30-inch specimens yielding less than a 12-inch one.

The boiling of the fresh latex requires skill. It is cooked

for one to two hours in kettles. When a moisture-content of about 33 per cent is reached the chicle is poured out onto a greased canvas and molded into marquettas of about 25 pounds weight. Four of these blocks are packed in a bale and two bales make a mule-load.

The Mayan chiclero collects about a ton of gum a season, from 200 to 325 trees. He is paid around 12 cents a pound, but not always in the coin of the realm.

Zapote is rarely cultivated in orchard form and then only for the sugary fruits. The tree does well in the Philippines, but as a gum crop it is Central American. The Mayas chewed chicle before the Iroquois chewed the more flavory spruce gum.

The United States consumes some 6,000 tons of chicle per annum, of which Mexico and Honduras furnish the major part; the import price runs around 50 cents.

CAMPHOR

The camphors are interesting resins. The principal one, *Cinnamomum Camphora,* is related to the cinnamon and native to Formosa, China, and Japan. The older one, Borneo camphor, *Dryobalanops aromatica,* is properly known as borneol or camphol. Camphors are found in many species of plants; the common garden sage contains a camphor, and menthol is simply peppermint camphor.

Chemically, the camphors are ketones or alcohols of the terpenes; but commercially camphor is a stearoptene, *i.e.*, the solid portion of the hydrocarbon which distills over in the vapor and separates itself from the liquid camphor oil.

The forest camphor tree in Formosa reaches a great height; in parks in Japan very old trees attain a diameter of 3 or 4 feet but do not grow tall. The Japanese government has taken firm control of the Formosan forest stands and there is now no fear of a sudden shortage of the resin. Two forms are known—one yields mostly oil, the other mostly hard gum.

Camphor has been planted in many countries with no

great success. The fact that the leaves and twigs, as well as the wood, may be distilled with fairly good results led to the cultivation of seedling trees which may be pruned back once or twice a year. Trial fields were set out, the seedlings about 8 or 10 feet apart, and it was found, especially in Florida, Texas and California, that the trees could be clipped the third year and at intervals thereafter. The clippings give 1½ to 2½ per cent of solid camphor.

Japan has maintained a system of planting large areas in Formosa, but depends on the wild forests for the bulk of the resin, about 75 per cent of the world's supply. An acre of Formosan camphor is reported as yielding about 120 pounds a year on an average; an acre of the close-planted clipping trees may yield 200 pounds or so.

The aborigines of Formosa invented a simple kind of wooden still for their use. The steam and vaporized resin and oil were collected in an inverted box set in water and cooled by a stream of cold water falling on its top. Some of the resin escaped and the water absorbed some of the oil, but the apparatus could be set up anywhere near a stream of water.

Plantation camphor would be successful with cheap labor, cheap land, and dear camphor.

A camphor-like substance has been prepared in the laboratory from oil of turpentine. One of the latest substitutes is methylisopropylcyclohexenone.

United States consumes, largely in celluloid manufacture, some 2,850 tons of camphor a year.

TREES WITH OILY SEEDS

The mahwa or mowra, *Bassia latifolia,* and the sister species, *B. butyracea,* are important often cultivated leguminous trees of south and west India, which furnish large quantities of very oily seeds and very sweet flowers. The latter are eaten and are also used for the production of cheap alcohol on a large scale. Another species, the illipé

PLATE XIX.—Model Pará rubber plantation in Philippine Islands, three and one-half years old; excellent legume cover-crop retains moisture, supplies nitrogen, and prevents weed troubles.

of Malaya, *B. longifolia,* produces large seeds containing a heavy percentage of a vegetable tallow with a great variety of uses in trade; its flowers, also, are dried and used for food.

The tamacoare, Caraipa sp., of the Amazon region is a common tree bearing abundant crops of seeds containing 52 per cent oil. Likewise, the bacury-assu, *Platonia insignis,* of the lower Amazon bears a fruit with an agreeable pulp and a very oily seed which will some day be in the trade.

Shea butter or emi, *Butyrospermum Parkii,* is a large Sapotaceous tree of French and Portuguese Guinea and the hinterlands of Liberia and Nigeria. The grayish tallow, made from the large fruit by crude native methods in the forest, comes down to the coast in cabbage-shaped balls wrapped with large green leaves. These lumps are pressed into hogsheads and shipped to Europe for sundry purposes —from soap to chocolate adulteration. In West Africa this ill-looking and odorous fat is used in cooking. A few small factories are operating, as at Bamako in the western Sudan, 20 tons a day; but little has been done with either export of the dried nuts or the local extraction of the butter. Yet this is one of the greatest sources of cheap vegetable oil in the tropics. In French West Africa alone it is estimated that 500,000 tons of shea nuts go to waste every year, half that amount in Nigeria, and as much more in the intervening colonies.

The other great oil-nut tree of West Africa, the koma or okoto or African butter-tree, *Pentadesma butyracea,* is of considerable importance to the natives, as a source of cooking fat. The 6-inch ovate fruits contain several large seeds full of a yellow waxy oil. The large tree, of the Guttiferæ, is very abundant around the Guinea Gulf, and will be utilized. A tree is said to yield 150 pounds of seeds, or 70 pounds of fat, a year.

The Brazilian pracachy, *Pentaclethra filamentosa,* is a promising leguminous tree. The edible seeds are half oil.

The mahuba, *Acrodiclidium mahuba,* also Amazonian, has

large seeds, the tallow (50 per cent) of which has a very high melting point, 109.4° F.

The immense and beautiful piquia, *Caryocar villosum,* common throughout the Amazon Valley except in the varzeas, or flood-plains, has a remarkable fruit: the edible pulp contains 45 per cent oil while the kernels contain 50 per cent. A tree is said to yield 5 to 8 gallons of oil a year.

Another very common tree throughout the Amazon Basin is the ucuuba, *Virola surinamensis.* Its numerous seeds are full of a wax-like tallow, highly suitable for candles and soap. A tree yields "around 22 pounds of tallow or wax" and grows rapidly. It belongs to the Myristicaceæ or Nutmeg family. An acre is estimated to yield over 3,000 pounds of this high-melting-point fat.

The old mafureira or mafurra, *Trichilia emetica,* of the Mahogany family, native to the beautiful open veld country of Gazaland and adjacent parts of Portuguese East Africa, is an almost ideal oil-seed. The tree is very productive and grows with such a dense head that the ground is bare beneath, thus making it easy to sweep up the fallen seeds. It stands out where trucks or launches can collect the enormous long-season crop. The practically shell-less kernel contains three fats: a greenish oil, very edible; a gray-green butter; and (under pressure after boiling) a dark grayish tallow of strong odor. Several times in the last thirty years the mafurra has figured quite largely in trade.

The manduro, *Balanites Maughamii,* is another promising oil tree growing along with the mafurra. The nuts yield a clear oil which the natives use in place of kerosene.

The Polynesian kukui or candlenut, *Aleurites moluccana,* is the tropical sister of the tung-shu, or Chinese wood-oil tree of the north temperate zone. The kukui, or bankul, is a medium-sized grayish-leaved tree, sometimes cultivated, and half naturalized in many countries. The kernel within the hard shell is so full of oil that it was used for lighting throughout the Pacific archipelagoes till kerosene came. A bamboo splinter run through a dozen kernels

and stuck into the floor or wall of the hut made a fair candle.

The crab-oil tree, *Carapa guianensis,* is common all over northern South America; the Brazilian name is andiroba. The amount of oil is not very large in the fleshy seeds but they are cheap and plentiful.

From Papua to southern India and from Indo-China to Queensland the jungles in many places reek with balsamic odors. Tall trees of the great genus Dipterocarpus, containing 65 described species, are prominent features of this vast area. Many of them are soft-wooded but all of them have resins, balsams, and oils in their leaves, bark, and sapwood. Many of them have not yet been described, much less studied economically. They vary individually and the species run close.

Lophira alata (Dipterocarpaceæ) of Sierra Leone yields "meme," or "kiam," butter used in cooking.

In Borneo and Celebes there are several species of Shorea, Pinanga, and Isoptera (especially *I. borneensis*) which bear heavy crops of large seeds from which the much-prized "tangkawang tallow" is obtained. This hard fat is extracted on a large scale, mostly in Germany and France, largely for use in soap manufacture. When the nuts are crushed and boiled locally, the crude product goes out as "minjak tangkawang," but since it is the product of six or eight distinct species it follows that no two lots are alike. These tallows are still wasting by the thousand tons, waiting for organized industry. So great is their oil-content in some Philippine and Malayan species that they may be tapped like the sugar-maple—a hole bored into the trunk, spout inserted, and receptacle suspended. The resinous oil, which runs from any wound in bark or wood, may have much or little sap mixed with the hydrocarbons. These so-called oils of the Dipterocarps may in the near future play an important part in international commerce.

In the tropics of the New World the Burseraceæ replace the Dipterocarps of the Orient. Many species exude great

quantities of white, yellow, or reddish resins and oily gums. The tabanuco or torch-wood, *Dacryodes excelsa,* of the West Indies often covers the ground around the trunk base with a fragrant mass of white resin; this substance has been studied chemically and found to be a separable mixture of hard resins, soft balsams, and several quasi-oils, heavy and light.

EDIBLE TROPICAL NUTS

The number of edible nuts is also very large. Probably only about one-half of the edible seeds and fruits of tropical trees have been studied.

One of the most important nuts in trade is the Brazil-nut, Bertholletia species. This tree is one of the largest in the Amazon Basin, and the heavy fruits falling from a height of 75 feet or more cause many deaths annually among the native "castanha" collectors. The Upper Orinoco juvia, *B. excelsa,* and the castanheiro of the Amazon Valley, *B. nobilis,* do well under cultivation. Two species of Lecythis furnish the cream, sapucaia, or paradise nuts of northern and central South America. The creams are somewhat richer and better-flavored than the Brazils and recently are beginning to be cultivated very successfully. United States consumes from 11,000 to 26,000 tons of cream and Brazil-nuts, the value running between $2,000,000 and $3,000,000 annually; this amount could easily be doubled at the producing end.

There are also several excellent souari, or butter-nuts, of the genus Caryocar (Ternstrœmiaceæ) native to the Guianas and north Brazil. They are the largest nuts, excepting, perhaps the recently discovered okari-nut (*Terminalia Kernbachii*) of Papua, outside of the palms. The souari fruit, like the Bertholletia, is 6 to 9 inches in diameter.

The genus Canarium of the Philippines and East Indies has some 80 species, about 10 of which bear edible nuts. The famous pili, *C. ovatum,* is often exported in consider-

able quantity from the Philippine Islands. The pericarp of the beautiful large plum-like fruit may also be eaten, cooked or raw. Gum elemi, one of the highest-priced resins, exudes in fragrant white masses from the trunk. The texture of the pili and the Moluccan kanari, *C. commune,* kernels is so soft and so very nutritious (73 per cent oil) that an infant food has been made therefrom. Both these species are entering the domain of agronomy; there are four others as good.

The cashew-nut tree, *Anacardium occidentale,* native to tropical America and a relative of the mango, bears a peculiar juicy fruit having the curved seed at the distal end, outside. The very rich kernel is better flavored than almost any other nut in the world. Vast stands of this homely smallish tree occur in northeastern Brazil, and thousands of tons of the kernels could be exported. The fruits are fermented to make "kajú," a very intoxicating liquor which has been bottled for the trade. Even Mozambique has thousands of acres of this New World nut. In 1925 over 2,500,000 pounds, probably not 5 per cent of the possible output, were exported, the bulk going to British destinations.

Tonka beans have been used largely as a flavoring and scenting material for more than half a century.

The cumarú tree is a legume, now known as *Coumarouna odorata,* formerly *Dipteryx odorata.* It is a tree of the forests and plains of Venezuela, the Guianas, and the lower Amazon Basin. Most of the trade supply comes through La Guayra into Port of Spain, Trinidad, where it is processed for export. The fruit, instead of being a pod, is plum-like and fleshy, containing one long (1 to 1¾ inches) black seed with the pronounced odor of vanilla and sweet-clover. These seeds after removal from the pulp are put into hogsheads containing a little old rum. The alcohol penetrates the firm tissue of the seed, and when the seeds are removed after a few days or weeks immersion in the liquor, fine sharp crystals of coumarin are formed on the outside of the seed skin. These very fragrant seeds, after drying, are shipped

in closed packages to Europe and America for the manufacture of a cheap vanilla substitute and for flavoring and scenting not only chewing, but also smoking and cigarette tobaccos.

A potentially important group of trees are the nittas, or nétés, of West Africa. They belong to the genus Parkia (Leguminosæ), of which there are some twenty species. *P. africana* is the doura of the Sudan; it has many uses among the various tribes. *P. biglobosa* of western tropical Africa has large long pods filled with a farinaceous pulp (31 per cent sugar) from which a nutritious but odorous drink is prepared. The seeds are made into a flour. Their analysis is reported as exceedingly rich: 36.2 per cent nitrogenous matter, 22.75 per cent fats, over 12.5 per cent of sugars and some 15 per cent starches, a natural concentrated ration and used as such by the natives when traveling.

The Inga species (Leguminosæ) have been mentioned as coffee shade trees in use in several countries of tropical America below 2,500 feet elevation. Several others, like the guavo (*I. spectabilis*) of Panama and the pacay of Peru (*I. Feuillei*), are cultivated for their pod fruits. The pulp of the former is extremely sweet and of agreeable flavor. The pacay has two-foot pods filled, as in the case of the Mexican inicuil (*I. Inicuil*), with edible pulp.

CHAPTER XVII

THE TROPICAL FIBERS

About 90 per cent of the world's fibers are virtually tropical, although much of the cotton and hemp is produced in the north temperate zone. Silk and wool are not true fibers. Flax is about the only large trade fiber which belongs mostly in the temperate zones. Hemp is grown as a temperate zone fiber and a tropical zone drug.

The three great crops, cotton, abacá, and sisal, are by far the bulkiest commodities in international commerce. At 20 cents a pound for the fiber, the cotton crop is worth between $2,000,000,000 and $3,000,000,000 a year without reckoning over a third of a billion for the seed value.

More than 1,000 plant species produce fiber of some grade. The Philippine Islands alone have 750 fiber-producing plants of potential value. In this chapter, therefore, only the principal tropical species may be noted, and of some of them only brief mention may be made.

COTTON

Cotton, the world's greatest industrial crop, apparently had three or more separate origins. From time immemorial the peoples of India have used the floss of *Gossypium herbaceum*. It was well known about 800 B.C. Toward the close of the classic era of ancient Egypt a tree-cotton, *G. arboreum*, was brought down into the Nile Valley from Nubia or some country in the eastern Sudan. The Incas and the Aztecs and their predecessors had been growing *G. peruvianum* and *G. hirsutum* respectively for ages when the conquistadores arrived on the scene.

Some 30 species and 100 or more named varieties of this great genus of the Malvaceæ are now known. Hybrids are easy to make, and since 6 or 8 pounds of seeds serve to plant an acre, the cross-breeding, accidental or otherwise, began early. The origin of the longest-fibered cotton, the "Sea Island," *G. barbadense,* is a mystery. It never has been seen wild in historic times. It was probably under cultivation by the Arawaks when Columbus reached the Antilles. The Amerinds used it for nets and fish-lines, having no need for fabrics.

There is scarcely a tropical region which has not originated one or more species of cotton. The ancestry of most of the cultivated cottons today is shrouded in mystery.

All the two dozen or so wild cottons are tropical, and practically all are perennial shrubs. In the great production centers, however, this crop is nearly always treated as an annual, largely because it is extremely susceptible to a multitude of bacterial, fungous, and insect enemies and the longer it stands the more attacks it invites.

Over half of the world's output, some 25,000,000 bales, is now grown in the southern United States. India stands second and China third.

There are so many factors in the industry—from trade balances and national policies to the lumbering problems in spruce forests (for rayon manufacture)—that the growers are never free from anxiety from one end of the season to the other.

The United Kingdom is naturally very desirous of becoming independent of the American crop, and great efforts have been made in several African colonies—not counting the Egyptian Sudan—to develop a solid status for cotton culture.

Inasmuch as cotton is not peculiarly a tropical crop, the details of its culture are not discussed in this book.

SISAL AND RELATED FIBERS

The agave fibers rank in importance next after cotton.

Their trade value is around $35,000,000 or more a year. The principal species are:

Henequen, or Yucatan sisal (*Agave fourcroydes* or *rigida elongata*).
Sisal (*A. sisalana* or *A. rigida sisalana*).
Mauritius hemp (*Furcræa gigantea*).
Maguey, or Philippine sisal (*Agave cantula*).
Zapupe (*A. Zapupe*).
Ixtle (*A. heteracantha*).
Cajun (*Furcræa cubensis*).

These rope and binder-twine fibers are rather localized and limited in extension. Only sisal is spreading. This is now produced largely in East Africa; Tanganyika and Zambezia are heavy exporters and Kenya now has nearly 55,000 acres. Java, Sumatra, Hawaii, and Haiti are beginning to produce some sisal. The total crop is some 80,000 tons as against about 120,000 tons for the Mexican henequen.

The maguey of the Philippines is of unknown origin, probably a cultigen. The output is now around 27,000 tons and slowly increasing.

Mauritius hemp is an American plant. It produces the longest of the agave fibers. In good soil the leaves reach 6 to 8 feet. The trade agave fibers run from 3 to 5 feet. It also has the longest peduncle known; the flower "pole," which after about five years shoots up with extreme rapidity from the heart of the plant, is reported as from 20 to 25 feet high or as much as 40 feet.

All these agave fiber plants endure droughts very well and most are satisfied with soft rock instead of earth. Mauritius hemp is the exception.

ABACÁ (PLATES XX-XXII)

The thirty or more varieties of abacá,[1] *Musa textilis*, are all strictly Philippine. They are "wild bananas," though of some varieties it would now probably be quite impossible

[1] This, being a Malay word, the spelling should be abaká.

to find a single wild specimen anywhere in the 1,750 islands.

These plants stand from 10 to nearly 30 feet in height and the fiber from the inner (but not inmost) leaf-sheaths runs from 6 to 18 feet in length, mostly 8 to 10 feet. It is the most elastic and one of the strongest fibers known. Unfortunately it is commonly called "Manila hemp" in trade parlance.

A hundredweight of the leaf-sheaths yields only about 2 pounds of dry marketable fiber. Two men with the old-fashioned knife-blade stripping machine can clean 100 pounds in about three days. Numerous machines have been patented and tried, but they are usually too heavy or too complicated.

The plants are set closer than ordinary bananas, say 8 to 10 feet each way. They produce the second year, and in good soil, with no disease, the plantation may last ten or even fifteen years. The acre yield varies, of course, greatly: ½ to 2 tons is the average.

Java and Timor have tried to compete with the Philippine Islands, but the abacá there seems not to thrive.

Several serious diseases threaten the industry and it will probably not increase greatly. The annual crop is around 200,000 tons. The price fluctuates greatly, from 5 to 12 cents a pound.

Besides *M. textilis* half a dozen other species of Musa yield a fiber similar to abacá. The lustrous sinamay cloth of the Philippines is hand-woven banana fiber, as is the bashofu fabric of Japan, from *M. Basjoo:* The Malayan jungles are full of wild bananas, often in vast pure stands, and some day their fiber and that of the common plantation banana as well will be utilized for paper or fabric stuffs.

KAPOK

Kapok, or silk-cotton, is steadily advancing. This extremely cheap short-staple cotton-like floss is used largely when spinning is not necessary, in mattresses, pillows, and life-preservers. Resiliency is the main advantage over

the loom fibers. United States now imports about 8,000 to 9,000 tons per annum, worth about $5,000,000.

Ceiba pentandra is undoubtedly an American species but now the Far East, and even Africa, suits it perfectly. The botanists may have to separate the giant ceiba of tropical America from the much smaller kapok of the Orient. It grows rapidly and lives to a great age; bears at 15 feet and reaches 75 feet. Several similar trees produce various seed flosses, some very beautiful, in various sorts of pods (long capsules). Tropical East Africa seems to be their favorite habitat. Neobarrettia is one of these types from Zambezia.

Java leads all countries in output, some 12,000 to 15,000 tons a year. The Philippines come next with about 500 tons; then Ceylon with perhaps 400 tons.

A mature tree may bear up to 1,000 pods or more; about 100 pods are required for a pound of the white, yellowish or brownish floss.

Kapok seed is forging ahead. In the Marseilles oil mills they are now extracting as high as 23 per cent, instead of the 18 per cent as at first. The press-cake is known, at least in the Malayan countries, as boengkil—on a par with and a small competitor of poonac from copra. Kapok-seed oil is now used for human food preparations as well as for soaps.

A similar prickly-stemmed tree in India, *Bombax malabaricum*, gives a fine reddish-brown floss.

Pochote is a superior kind of kapok produced by two Mexican trees, *Ceiba acuminata* and *C. æsculifolia*. The beautiful and highly resilient floss commands an import price around 30 cents a pound. Its cultivation is just beginning. Like kapok, it can probably be propagated very readily by means of large 5-foot stake cuttings which bear pods in less than two years.

JUTE

Jute is the second greatest fiber in the world. It is almost entirely an Indian crop, though the two species,

Corchorus capsularis and *C. olitorius,* may first have been domesticated in Malaya or Ceylon.

In the alluvial plains of the great Ganges and the Brahmaputra some 3,000,000 acres are under cultivation in this crop. Every civilized country imports some form of Bengal gunny—burlap, bags for sugar and rice, carpet material, and the like. The United States imports some 60,000 tons of raw jute, worth about $12,000,000; of gunny sacks, about $6,000,000; and of all jute and manufactures, over $100,000,000. The crop is worth over $200,000,000.

There are a dozen or more main varieties of these two half-shrubby members of the Tiliaceæ. Planted close in good soil the stems shoot up rapidly to a height of 8 to 12 feet, and with practically no side branches. Though only three or four months are required for taking off the crop, jute land seems to require rotation, as jute, rice, rape, and mung or some other legume, but not two jute crops consecutively.

The long stiff stems are retted in pools or tanks for one to three weeks to rot out the soft tissue from the bast fibers of the bark; these stems are then whipped onto the water and the loosened strands of gunny are hung in the sun to dry.

Jute has often been tried outside of Bengal, unsuccessfully.

The pan-tropical weed in all cultivated fields known under many names to the farmers and as *Urena lobata* to botanists is strikingly like the jutes. Though belonging to another family (Malvaceæ), the "patu-epala" of Ceylon, the "cadillo" of the Antilles, and the Brazilian "aramina," has the same habit and size. The author has produced, by the jute planting system, 12-foot nearly branchless stems in Porto Rico.

Urena fiber has not been considered so easy to extract as jute, but a new process is reported which, if practicable, may make it a serious rival to gunny. It seems to bleach well and may even compare with ramie. It may become one of the world's cheapest and best fibers.

HEMP

Hemp, *Cannabis sativa,* is a three-crop plant, yielding fiber, oil and drugs. It is closely related to the fig, originating probably in central Asia, and for ages played a prominent part in the economic, and even social, welfare of many countries. It is diœcious. Hemp is both tropical and subtropical. In the tropics, especially in India, it is grown for its seed, for oil, and for its resin.

The three or four alkaloids contained in the gum in its sap are among the most powerful known, and the great wonder is that hashish in some form has not ruined the population of southern Asia and eastern Africa, where almost every kraal has its "dakka" bush. Bhang and ganja are the crude unstandardized forms of Indian hemp, while charas is the resin, which is finally being standardized, like morphine.

Hemp fiber is nearly white, very strong, and quite durable; usually about 2 yards in length; nearly 25 per cent of the dry stems (8 to 12 feet high) is fiber; 2 to 3 tons or more of dry stems can be taken from an acre. There is no better fiber for ropes, canvas and carpetings; but for various, rather obscure, reasons it has never been widely cultivated.

MISCELLANEOUS FIBERS

Flax has long been grown in the temperate zones for fiber and seed. It is now coming to be a tropical crop. Brazil, India and particularly Kenya are developing its cultivation.

Ramie or "China grass," *Bœhmeria nivea,* is for the most part subtropical, but India, Formosa, and tropical China are producing considerable quantities of this brilliantly beautiful fiber, or "filasse." It has failed in tropical America.

The sansevierias, or bow-string hemps, of Africa and southern Asia have from time to time been popular. Nowhere have any of the four or five cultivated sorts given satisfaction. Some work has been done in extracting the

strong nearly white fiber in East Africa where large areas of wild plants could be drawn on. They belong to the Liliaceæ. Propagation may be effected by leaf-cuttings; even short pieces of the leaf promptly develop roots from the lower edge.

San, or as it is usually written Sunn, hemp, *Crotalaria juncea,* is very widely cultivated in India and to some extent in Ceylon and Java. Several hundred thousand acres, mostly in small fields, are planted in San in India for three or four months in the rainy season. It is, with several other species of the genus, grown in many countries where a quick-action legume nitrogen-gathering crop is demanded. It is grown like jute, with which it competes.

Rama or roselle, *Hibiscus Sabdariffa,* appears to be a West African cultigen, and indications are that it may become a famous fiber. It was introduced into the Philippines in 1913, where it displayed striking properties. It quickly reaches a height of 10 to 15 feet, with almost no side branches. There are several sorts at least, red and green types. The stems are retted like jute; the fiber is then bleached in the sun and cleaned. The short stinging hairs interfere somewhat with the harvesting operation.

There are two distinct species of palms in Brazil which produce piassava for export. The word is evidently of Amerind origin, but the West African article is the bulk of the trade which runs to a few thousand tons per annum. These basts, or bundle fibers, are stiff coarse splinty material used for brushes, brooms, mats, and the like. The majestic wine palm, *Raphia vinifera,* of Liberia and the Guinea Coast countries is, with a sister species, the source of piassava. Along the hundreds of brackish bayous and tidal canals are millions of these huge palms; the 30- to 40-foot petioles are retted in these creeks till the long wiry fibro-vascular bundles can be beaten loose from the softer tissue of the great midrib. It is back-breaking work and dangerous, to stand knee-deep in the black mud, rain or shine, mosquitoes and Glossina pestering, and flail out this piassava. It will probably never be cultivated.

Raffia is simply the under-side cuticle of the leaflets of another species of Raphia, *R. Ruffia,* indigenous in Madagascar. Of the numerous palm fibers this is the softest, so silk-like that it may be woven into delicate fabrics.

There are several palm leaf-sheath fibers in trade, such as the gomuti brush and rope fiber from the sugar palm, *Arenga saccharifera,* kitul bristles from the toddy palm, *Caryota urens,* and Palmyra bristles from *Borassus flabellifer;* but the great palm fiber of the world is coir, the coarse brown fiber of the coconut husk. This cheap, short, rough fiber is exported mostly from Ceylon and the adjacent coasts of the Deccan Peninsula; the former country ships some 25,000 tons a year. Retting and beating by hand is the principal method, though several machines for its extraction have been invented. Coir and cabo negro, or gomuti, ropes are the most durable in sea-water. Coir cables are somewhat elastic—used in towing. It is reported that a Dutch patent may soon expand the coir industry; the machine is to extract the fibers, sort them, then spin and weave them.

Loofa or luffa, *Luffa cylindrica,* is a unique sort of fiber. No one would expect to find vegetable sponge, a lacy network of stiff, curved but not curled fibers, in a cucumber. The fruits of this lush cucurbit vine are 8 to 10 inches long, nearly cylindrical, with a bitter pulp and plenty of seeds. The fruits, retted in water, yield a skeleton of the yellow wiry fiber which has a variety of uses, from bath sponges to hats. Japan exports it in quantities. Another species, *L. acutangula,* has sharp ridges on a longer fruit.

Jipijapa is the Amerind name for a stemless palm-like plant, Carludovica species, of the Colombian and Ecuadorean humid forests. It belongs to a small family, the Cyclanthaceæ, a sort of connecting-link between the aroids and the palms. It is the sole source of the very flexible and durable fiber "toquilla," from which "Panama" hats are made. Probably no regular plantation of jipijapa, or "jippi-jappa," exists anywhere. The wild plant usually stands about 6 to 10 feet high, but the author has found

them 18 feet in Canal Zone jungles. The very young leaves only are used just as they unroll from the bud. The entire leaf is shredded into narrow thread-like strips, the toquilla, and these are scalded, then bleached with sulfur.

Several bromeliads yield hard, white or yellowish, fine fiber. The nanas (the name harking back to Brazil) of the Philippines yields the shining extremely durable fiber for piña and (with silk) jusi cloth. Other varieties of pineapples are cultivated in Formosa and south China for their fiber. In Colombia and Panama there are two or three forest species, related to the pinguin and pineapple, with prickle-margined leaves 8 to 10 feet long. All these bromeliad leaves yield only 2 to 3 per cent of fiber by the hand-stripping method. Some acres in the virgin forest or its outskirts would yield many tons of leaves continuously, the only expense being the cutting of the older leaves and their transportation.

Throughout Polynesia the "tapas," or bark cloths, prepared from the inner bark of *Broussonetia papyrifera* and other trees, were the principal clothing material worn by the natives up to half a century ago. In Ceylon and Dutch Malaya the upas, *Antiaris toxicaria,* furnishes a very serviceable substitute for cloth. The M'chopes tribe of Gazaland in Mozambique has, for centuries probably, conducted a good barter trade in "mutshus," or sarong-like cloths reaching from the hips nearly to the knees. They have worked out a system whereby they obtain straight smooth trunks, 6 to 10 inches in diameter, of a semi-cultivated fig, *Ficus Nekbudu,* discovered by the author in 1908 and described by Sim in 1909 as *F. utilis.* A sleeve of bark 2 to 3 feet long is removed from the trunk; this is spread out on a log and pounded with mallets till the soft mesophloem tissues can be washed out; the reddish bast, about ⅛ inch thick, lasts a year or so in use. In Zambezia the author has seen mutshu cloth being made by chewing. Hundreds of tons of groundnuts go down to the East Coast in bark cloth bags, 60 pounds to a load.

PLATE XX.—Abacá (*Musa textilis*) in its native habitat, Albay Province, Philippine Islands.

CHAPTER XVIII

GRAINS AND FORAGE

With exception of the Levantine and European cereals, such as wheat, rye, barley, and oats, most of the great grain and forage crops of the world are of tropical origin. Some, as maize and rice, are now grown extensively in the temperate zone. Others, as adlay, are amazingly restricted in regional culture, while the pigeon pea and others are cosmopolitan cultigens of unknown origin. The grain, forage, and root-crops are the solid foundation on which rests both human and domesticated animal life in the torrid zone.

RICE (PLATE XXIII)

Rice is the world's most important crop. It furnishes food for a billion persons. The value is over $7,000,000,000, or nearly thrice the trade value of the great trade crop, cotton.

Where this grass was first domesticated can never be known, but at the dawn of Sanskrit history it was an old crop in India. Southeastern Asia or perhaps south China may have been its cradle. Today the acreage may run to over 200,000,000 acres in the tropics. The total crop may weigh over 180,000,000,000 pounds. The Orient produces some 95 per cent of the rice.

There are numberless varieties of rice. Japan, China, India, and Philippine Islands each have about 1,000 distinguishable kinds, while Ceylon, Dutch Malaya, Siam, Burma, and Indo-China have from 200 to 500 or more each. Allowing for the surprisingly few duplications between one country and another, it is safe to say there are from 5,000 to 7,000 distinct sorts of this great cereal.

Of types there are really only three, the wetland, the

upland, and the perennial. Attempts have been made to classify the varieties by seed characters.[1] The Bureau of Agriculture of the Philippines has catalogued several hundred varieties, giving synonymous names, cultural data, and the like. Grown intensively for probably more than 7,000 years, it is not surprising that *Oryza sativa* has varied tremendously; remarkable it is, though, that practically every variety comes absolutely true to seed. It is strange that the rice-eating peoples have never till recently exchanged varieties with one another; for instance, a certain valley in Luzon may have long been growing forty kinds, and ten miles away another valley may have the same number of sorts, yet there are probably not five varieties common to both valleys.

The rice varieties are not so differentiated as are those of maize, but the variations are very interesting. Some sorts mature in 60 days while others take 225; some stand barely a foot high, others even without irrigation may reach 7 or 8 feet. The average yield is probably less than 25 bushels an acre, but over 100 bushels is not very rare.

There are many red-seeded sorts, yellows, browns and even brilliant blacks, white being the commonest color. The seed size varies several hundred per cent. The flavor of some upland types is delicious, likewise the fragrant aroma while cooking. Most of the better-flavored sorts are never in trade, their local value being perhaps five times that of the cheap tasteless varieties which are grown only for export. Some varieties pop like pop-corn.

Rice is impatient of weed troubles and dry weather. Probably 75 per cent of the world's rice is planted or transplanted in level diked fields of mud and as soon as the young plants are tall enough water is let onto the field at intervals,

[1] Wester makes a very convenient but artificial classification of rice varieties into 16 groups: first the two great divisions, upland and lowland; then there are glutinous and non-glutinous types of each; of each of these there are awned and awnless sorts, and of each of those sorts there are white and colored forms.

The Philippine Islands produce some 2,000,000 tons.

thus killing most of the weeds. Irrigated rice requires cheap hand labor. In many localities there is only one crop a year and no rotation, the fields merely lying fallow half the year.

Most of the threshing is done without machinery.

Millions of tons of rice straw are burned every crop. If pressed into briquettes this could at least be used for fuel or ground for roughage feed which is in such demand in Europe. The hulls, or chaff, are usually burned as fuel in the de-hulling mills. The ash is, of course, wasted as it cannot be used in feeds on account of the silica. Rice middlings, or tikki-tikki, is perhaps the richest of all similar stock feeds; it contains phosphorus and proteids, the human-food portion lacking these valuable ingredients.

In Japan sake and in China samshui, rather weak water-colored liquors, are made from fermented rice meal and broken grains.

More attention should be paid to the upland varieties, some of which are more prolific than any irrigated type. Vast areas of cheap land in many countries could be put into rice in rotation with maize, cotton, tobacco, and it could be grown as a catch-crop in rubber and fruit plantations.

The pests and diseases of rice are not very serious.

MAIZE [1]

Maize was domesticated by the pre-Inca races in the central Andean region. A fossil ear some two inches long was found in Peru a few years ago and the oldest mummy burial mounds contain ears of nearly the same type. It is obvious, therefore, that a wild plant with small but quite edible seeds was taken over by those marvelous agriculturists of that region, and, together with some 75 other economic species, was planted on mountain-slope terraces

[1] Collins, G. N., "A Fossil Ear of Maize," Journ. Heredity, Vol. X, No. 4, 1919.

Collins, G. N., "An Ear of Prehistoric Maize That Resembles the Fossil Form, *Zea antigua*," Journ. Heredity, Vol. XIV, No. 2, 1923.

at least 2,000 years ago. For many centuries it has been a cultigen.

About eight or ten centuries ago the Aztecs regarded maize as a divine gift and depended largely on it as the staff of life. Any "kern" or kernel may be called a corn and Indian-corn is the old name for mahiz, maíz, or maisí; but only one country persists in calling it by the vernacular name "corn."

There are six or seven types of this grass. Two, the Dent and the Flint maizes, are now very extensively planted in United States, Argentina, Australia, and South Africa. The sugar, or sweet, maizes are largely consumed, fresh and canned, in United States. The pop and flour types are unimportant.

Maize is usually considered a strictly temperate zone crop, and truly excellent yields are often obtained therein; but, given the right physical conditions and acclimated variety, tropical maize is better than temperate. In southern Mexico, the Canal Zone, and the Philippine Islands this crop in good soil may reach a height of 15 and even 20 feet; the lower ear on a 19-foot stalk can hardly be reached with the machete in the hands of an average-size laborer. Two crops a year can be grown in the tropics; some type of bean or cowpea is usually interplanted with the major crop.

A popular belief exists to the effect that maize is too heating for a tropical diet. Mexico, Spain, and United States are the only countries that have learned how to eat maize properly. In Mexico the hull is removed with weak lye, the paste of the kernels then being toasted in tortillas. In Spain the toasted kernels are pulverized, this powder then being mixed with other materials if desired—gofio. Maize meal and flour in the United States when thoroughly boiled, toasted, or baked is a very wholesome foodstuff. Very unfortunately most peoples have not yet learned how to cook maize. They fail to comprehend that the flinty particles of this seed require not twice but four times as

long to cook as does rice. Eating partially cooked maize meal may cause intestinal disturbance, and this, not any lack of flavor or richness nor any question of cheapness, explains why maize is today unpopular in most countries as a human food.

Nicaragua surpasses all other countries in the variety of ways of using maize: pinol and pinolillo are combinations of the roasted kernels with sugar and chocolate, and may be drunk in water or eaten in many ways. Eastern Java maize fields are now feeding many millions. The South African mealie crop is hardly excelled anywhere.

Some types mature in 90, while others require 150 days. Probably over 1,000 varieties exist; most of them are recent.

The world crop is between 4,000,000,000 and 5,000,000,000 bushels. The value is around $2,500,000,000. It is fourth in value as a food crop.

Maize is undoubtedly extending gradually into the tropics. Both as a forage and grain crop it deserves a front-rank place among the world's cereals.

MILLET

The millets, as a group, rank next to rice in the tropics. Since so many plants pass under this name in literature, it may be well to put each in its true botanical place here:

Holcus Sorghum or *Sorghum vulgare* is the genuine millet of China, India, and Africa. It includes the kaoliangs of the ancient Chinese agronomy—one of that country's most important crops, furnishing grain, sugar, and forage for thousands of years; the douras, or jawaris, of India, of many varieties and over millions of acres yielding bread grains and forage; and the innumerable kafirs of the entire African continent, giant grasses from 6 to 18 feet tall, and in many regions the basic cereal. Probably over 1,000 varieties are under cultivation and most of them are old. These grain and sirup millets are extending away beyond the tropics. Many kinds will bear heavy crops in dry regions where maize or rice would be unable to survive.

Eleusine coracana is the jurracan, or ragi, or African millet. It is commonly cultivated from Dutch Malaya to north Africa. It is a good crop for bad soils. Like rice, ragi is of two types, upland and irrigated, a fact not generally known. In India heavy yields are obtained, up to 1,500 pounds to the acre.[1] Bread is made from it.

Pennisetum glaucum is the old Pearl, Indian, or African millet of very wide cultivation. It is an excellent grass, 4 to 8 feet high, with heavy cylindrical heads of white grains. *P. typhoideum* is the Bulrush millet of Africa and the Orient. It has typha-like heads, as with the Pearl, of which it may be considered a sub-species.

Setaria (*Chœtochloa*) *italica* is the so-called Italian, or German, millet, probably domesticated in the extreme Orient ages ago. It is five times as prolific as wheat.

Panicum miliaceum is the old Indian millet, very widely cultivated in many countries. It is probably native of Egypt.

Echinochloa frumentacea, the Cockspur, or Sanwa, millet is one of the quickest-growing crops in the world; theoretically eight crops could be raised on the same field in one year. It is also one of the best forages, and it is strange that it has not been more popular outside of the Orient.

Paspalum scrobiculatum is the Koda millet of India and Ceylon. It is a coarse grass with a prolific but dangerous grain.

Holcus Sorghum var. *saccaratus* is the name applied to most of the sirup sorghums and to broom-corn millet. The many types have many uses, as for fiber bristles, seeds for food, forage, and sirup.

The adlays are soft-shelled varieties of Job's tears, *Coix Lachryma-Jobi,* native to the Philippine Islands. Instead of the porcelain-like exterior of the ordinary type these

[1] Recently the Mysore (India) Agricultural Experiment Station has begun to create new and superior varieties of this sadly neglected major crop.

(var. *Mayuen*) have only a thin brittle shell. The size of the seed is the same. The twelve or more distinct sorts of adlays are huge grasses 5 to 8 feet high and very stooly, one seed forming a huge clump of ten to twenty suckers. The yield of grain runs from 25 to 40 bushels to the acre. The forage is excellent and it may be cut several times in the season. Adlay prefers rich moist soils. Adlay seed has very high protein-content; where rice has only 7.9 per cent and maize 9.8 per cent, adlay contains from 11 to 17 per cent or more protein. The fat-content also is high; 5 to 7 per cent as against 4.1 per cent for maize and 2 per cent for rice. These figures put adlay ahead of perhaps every other grain. The grain makes a very fair bread, alone or mixed with wheat flour. P. J. Wester has studied the adlays thoroughly and has great hopes that they will become the tropical bread grains of the future.

The Incas for centuries consumed large quantities of quinoa. These small seeds, of various colors, are profusely borne on erect weed-like herbs (*Chenopodium Quinoa*) about 5 feet high. Another species, *C. album,* is the bajar, or taku, of India; both the grain and the leaves are eaten.

Several species of Amaranthus are cultivated in India, the Philippines, and the Malayan countries both for their small seeds and their salad leaves.

THE LEGUMES

The pigeon pea, Congo pea, gandul, kadios, or dhal, *Cajanus Cajan,* is one of the most promising legumes of the tropics. While Asia may well have first domesticated pigeon pea, Africa has strong claim to that honor. In Porto Rico there are today about thirty distinct sorts of gandul while probably no other country can show half that number.

From beyond history cajan has been used for human and animal food, both immature and ripe seeds. As a great forage crop, however, it did not come to prominence till about 1920 when, in Hawaii, it was discovered that pigeon-

pea hay and green forage were about on a par with the temperate zone alfalfa so far as protein-content goes. The proteins are about 20 per cent, carbohydrates 50 per cent, and fiber 10 per cent. There are reasons besides its surprising richness for recommending it as the best legume forage crop for the tropics: it endures long droughts extremely well; it is not particular as to soil; it stands top-cutting or browsing at intervals; the slender branches themselves are relished by cattle; the leaves dry readily, and the flowers, buds, and pods with no great difficulty; the sun-dried hay keeps well if protected from humidity; it grows rapidly and lives two to seven years.

Six pounds of seed worth, say, 25 cents, will plant an acre; two or three seeds to the hill and the hills 3 or 4 feet apart. Plants stand from 3 to 16 feet high according to variety; some are leggy, others round-headed. The flowers are yellow, red, brownish, spotted, striped. The seeds are white, yellow, gray, brown, or spotted and round, oblong, or cubical. Some are the size of the garden pea, while others are only one-third that size; four to six in the pod. The seeds before hardening make a highly nutritious dish; ripe, they have a strong peculiar flavor and are believed to contain large amounts of iron and iodine. All kinds of poultry from pigeons to ducks are fond of the flowers, buds, and seeds. Horses, cattle, and goats revel on it. All poultry yards in the tropics should be planted with pigeon pea, both for shade and grain.

As a windbelt for garden crops cajan about equals *Tephrosia candida.* A close hedge 6 to 10 feet high can be grown in as many months. It stands heavy pruning; the prunings, incidentally, are used as first-class fresh forage or dry feed. When left in position for several years the stem may attain a diameter of 6 inches. By sowing broadcast 50 to 100 pounds of seed to the acre a very dense stand is secured which may be plowed under at the height of 2 feet or so.

While alfalfa may succeed in some tropical situations

where the lime-content of the soil is just right, it usually fails in the humid lowland regions. The cajan, however, with about the same feeding value, seldom gives any trouble; and the yield of forage to the acre may be ten times that of alfalfa, grown in the same field. All the cajans appear remarkably drought-resistant.

In Cuba and, it is reported, in northern India the gandul has become naturalized.

The dry pods, seeds removed, are an excellent fodder and in Porto Rico oxen are fed with this material sprinkled with water in which a little salt has been dissolved. The analysis shows some 5 per cent protein. The dry seeds contain over 22 per cent protein, about the same as beans.

In Madagascar silkworms are reared on cajan, and in India the lac insect.

There are rusts and leaf-blights which in the rainy season attack some varieties badly. A few root fungi may kill old plants.

The peanut, mani, cacahuate, or groundnut, *Arachis hypogœa,* is one of the great grains. This tropical Brazilian legume has long ago spread to the far corners of both hemispheres, the Old World now leading in tonnage but not in cultural development. The total crop is now around 2,000,000 tons and may increase; its rivals are cotton-seed, palm kernels, and the coconut.

Although enormous quantities are eaten locally in Africa, the peanut has never replaced the older legume seeds in India and China. Tropical America is rather too wet, but the dry coastal plains of French West Africa and Gambia are very well suited for peanut planting. Several hundred thousand tons are shipped thence to Europe each year.

The dry seed contains around 40 per cent of a bland white oil of which 32 per cent is extractable. It is used in blending with others in the manufacture of cooking fats and oils. The hulls and shells are largely used in cattle feeds and the cake from the seed presses is prized both as a strong fertilizer and as high-grade stock feed. Ceylon

takes some 35,000 tons a year of this peanut cake for her tea gardens, according to Macmillan.

There are some fifteen or twenty varieties,[1] the commonest being the small two-seeded Spanish. This dwarf sort is extremely hardy and easily harvested, the pods burrowing only slightly. Some varieties have five seeds to the pod; most have only two or three. The average yield is only about 60 bushels to the acre.

Peanut hay is very rich but sometimes too sandy for safe feeding. The foliage is quite susceptible to rusts.

The kandela, *Kerstingiella geocarpa,* is a peanut-like herb of the Guinea countries. Unlike the peanut it roots at the nodes, a very important quality. There are several varieties, some with red, others with black or white seeds. It is cultivated largely in Togoland. This crop is well worth breeding up.

Another rather important ground grain similar to the peanut is the vandzon, *Voandzeia subterranea,* of East Africa and Madagascar. Its habit is quite distinct from that of the peanut, and the dark-colored deep-burrowing pods are spherical and the size of a Concord grape. It has become naturalized in Surinam, as "gobbe."

The cowpea, *Vigna sinensis,* is a legume of great and growing popularity throughout the tropics and subtropics of both hemispheres. It is probably Asiatic in origin. It passes under several botanical names. There are six or eight very distinct types and sub-species; some have straight slender pods 4 inches long, in others the pliable pod reaches 3 or 4 feet. There may be 150 or more named varieties in general cultivation and perhaps as many more in the far corners of Asia and in the Malayan and Polynesian island groups. In most countries the ripe seeds are used like beans; in some the immature pods and leaves are also eaten.

Cowpeas are excellent swine forage, and when conditions

[1] Many hybrid varieties, some very promising, are now being produced at the Mysore (India) Agricultural Experiment Station.

permit an excellent hay may be made for cattle. There is hardly a better or safer cover-crop for plantations; they do not climb onto the major crop; they grow very rapidly, maturing in 60 to 100 days. Cowpeas are fairly free from fungous and insect pests.

Cowpeas may be planted in hills or rows or broadcasted. The stand may be from 1 to nearly 3 feet deep. They are excellent for preventing erosion because of their thick bottom growth. The amount of nitrogen cowpeas put into a soil is unusually large. Great care is needed in storing cowpea seeds as Bruchus beetles like nothing better. The value of the cowpea group to the tropical farmer is incalculable.

The silani, *Vigna marina,* is a striking cowpea-like species, apparently native to the Philippines. It has the remarkable habit of rooting at the joints, a stem thus extending several yards. The seed is scant and the old stems tough but it has great possibilities as a forage plant for low grounds.

The velvet bean group is another very important lot of cover-crops now cultivated throughout the tropics. No legumes excel them in rapidity and few in linear extent of growth. The true velvet bean, *Stizolobium Deeringianum,* may attain a length of 80 feet in about four months, or, 8 inches a day. However, there are one or two bush forms. These legumes are excellent for killing grass and weeds in interspaces, but are likely to injure the major crop plants. Even coconuts several years old may be killed in a few months if not attended to by poling off the vines. The hay is rich but difficult to dry without artificial heat. Fresh vines are best pastured as they are too rich for the stable. The seeds are edible, even when dry, but require special cooking, de-hulling and changing the water. Cattle relish the pods before they harden. Most forms have irritating hairs on the ripe pods.

The Lyon bean, *Stizolobium niveum,* is a closely related species from the Philippines. It can quickly form a

blanket 3 feet deep over even a grassy field. The seeds are eaten in India. Two or three other species have edible seeds.

The kudzu, *Pueraria Thunbergiana,* from Japan and *P. tuberosa,* a similar species from southern Asia, are rampant vines which produce not only forage but edible roots. They deserve attention.

The guars or cluster beans, *Cyamopsis psoralioides,* are little-known but very old legumes of India and Ceylon. They have been cultivated in the Orient for centuries, but till 1906 they were practically unheard-of in the western hemisphere, when dozens of varieties began to come out of the East. The seeds and young pods, 2 to 3 inches long and borne in clusters, are human food. The plants, 2 to 6 feet high, are forage. Guars are also grown for green-manuring.

The seguidillas, asparagus pea, or Manila bean, *Psophocarpus tetragonolobus,* is native of Mauritius and largely cultivated in Burma. The square pods, with leafy wings on the angles, have the pleasant flavor of asparagus but must be used before becoming woody. The plant also produces coarse fleshy roots, like the yam beam, or sincamas, Pachyrhizus species. Out of sixteen legume cover-crops the seguidillas gave the best results as a citrus cover in the tests conducted in 1924 by the Philippine Bureau of Agriculture. The dry seeds are among the richest in protein, nearly 30 per cent.

The sieva and lima beans, *Phaseolus lunatus* and *P. limensis,* comprise several botanical varieties and scores of garden ones. Some varieties were evidently domesticated by the pre-Incas. Some are probably oriental. All are thought to be cultigens. Some forms are bushy, others run to great length. They are highly nitrogenous food. The Tamil name pithanga and the Tagalo patani apply to vigorous varieties of great promise, for not only are they luxuriant cover-crops but the seeds are edible, though strong. This group needs much study.

The mungs or grams, *Phaseolus aureus* and *P. Mungo,*

are valuable little legumes of India, very ancient, presumably. There are black and green varieties or sub-species; the green cooks up well. There are no richer seeds for human consumption, excepting, perhaps, the soybeans and the peanuts. It is believed there are 100 or more varieties scattered throughout the many provinces of China; there is renewed interest in them in United States.

The lentil, *Lens esculenta,* which is one of the oldest legume crops, is probably native to southwestern Asia. The plants, green or dry, are a very rich fodder.

The lablabs, *Dolichos Lablab,* are perhaps the best flavored of all the beans. The seeds have a prominent hilum and are of many colors, shapes, and sizes. The plants are large and give almost continuous crops of pods for one to two years. Some sorts are bushy, others run 20 yards or more. The lablabs, or bonavists, are deserving of more attention. In the dry island of St. Thomas eight varieties are in cultivation, though seldom more than two or three sorts are known from any region. A purple-leaved form is cultivated in Rhodesia.

The Madras gram, *Dolichos biflorus,* of India and the el-dhambala, *D. bracteata,* of Ceylon, are, according to Macmillan, quite common crops in those countries, though not grown yet in the western hemisphere.

The soybeans, *Glycine Max,* are a large group of legumes. The 1,000 or more varieties are scattered from Bengal and Burma up through all of China and Japan to northern Manchuria, whence most of the world's commercial supply comes. This species has the rare quality of containing 13 to over 26 per cent of an edible oil. This oil has a great variety of uses, from food to a substitute for linseed oil and kerosene. Soybean cake is an important trade commodity and cattle feed. Sou was the old Chinese name. Several kinds of so-called cheese and several sauces are made from soybeans. These proteid curds, made by boiling, grinding, and coagulating the diluted seed paste are very wholesome and nutritious foods, though somewhat odorous to the novice. Shoyu sauce is used in enormous quantities

throughout the Orient; a very slow fermentation, with salt, finally produces a black liquid like cassareep. A milk-like preparation and infant and invalid foods are made from this "vegetable meat" grain.

Most soybeans do not endure the sea-level heat of the tropics. Painstaking trials will determine which of the many sorts can be grown in the higher altitudes. If not the 8-foot kinds, then perhaps the 2-foot ones will prove of high value to man and beast in the Occident, also. For more than a quarter century the United States Department of Agriculture has been testing soy varieties; some 900 or more sorts have been tried out.

Soybeans are the richest edible grains as to protein, 30 to 40 per cent. The chief proteid is glycinin; its amino-acid make-up is about the same as in animal flesh.

The chick-pea or garbanzo, *Cicer arietinum,* is one of the best legumes for human consumption. The large seeds are exceedingly nutritious. They are very prominent in international trade. As a striking instance of commercial complexity may be mentioned the fact that Mexico imports ordinary garbanzos from Spain but exports to Spain some of her very superior varieties, grown in the southern part of the high mesa. De Sornay states that "more than four million hectares" in India are in this legume (the same area as occupied by the sugar-cane of the world). This should return well over a million tons of the grain, worth over $100,000,000. There are many varieties; in Abyssinia and India there are black-seeded sorts. If any thorough test has ever been made of all procurable varieties it should be of great interest. The thick young shoots are cooked like spinach. The leaves and pods are very rich fodder, but the stems are coarse.

Of the true bean group, *Phaseolus vulgaris,* there are many types, and bean nomenclature is a difficult subject; the numerous hybrids confuse the matter, and there is a common latent tendency to sport among most types. There are probably 1,000 distinct sorts of this economic plant. Its

original habitat is unknown. The natives of the Antilles had several bean-like crops when Colón arrived, and De Candolle concluded that, since neither the lake-dwellers of Europe nor the Egyptians appeared to have known it, it must have come from tropical America. Neither the tropics nor the north temperate zone could dispense with this crop; it is in many regions the principal source of protein for the poorer classes. Incidentally, it may be remarked that the common varieties of the French, or kidney, type are seldom sufficiently cooked (or masticated) and so are not very digestible. In the writer's opinion all legume seeds, if consumed in the ripe state, should be finely ground; this flour cooks in half the time required for the whole seed, digests readily, and has the same taste.

The kidney bean is one of the few tropical crops which gives five or six harvests a year. It is preëminently a catch-crop. On account of its numerous fungous and insect enemies, it should be rotated.

The proteid-content of the dry seed ranges from 13 to 25 per cent; the nitrogen-content of the embryo is, according to De Sornay,[1] 44.5 per cent. The forage is relished by some animals but it should be used before the leaves begin to turn. Many varieties are eaten in the pod while not quite ripe; in the "string" state they are canned (with difficulty) in vast quantities, likewise when ripe.

This crop should be grown on all tropical estates for local consumption; if a certain variety appears ill adapted to the locality there are plenty of others, some of which are almost certain to prove suited to the particular soil and climate.

There are several other species of Phaseolus such as the exuberant *P. coccineus,* or Scarlet Runner, one of the fastest growing vines known. It originated somewhere in tropical America. The seeds resemble a coarse large lima bean, but are less palatable.

[1] De Sornay, P., "Green Manures and Green Manuring in the Tropics," 1916.

Phaseolus derasus is a little-known bean of Brazil, having black seeds with a white hilum.

Phaseolus trilobus is largely cultivated in India. The small greenish-yellow black-striped seeds contain nearly 24 per cent protein.

Phaseolus sphæricus var. *sulfureus* is a very old bean, probably native to China, now of wide cultivation in Asia. The bright yellow seeds are nearly spherical.

Phaseolus calcaratus is the rice bean of southeast Asia. It is a dainty quick-growing grain. The seeds—of various colors—are elongate, somewhat like rice-grains in size and shape, and very nutritious. This species has never received proper study, and the number of varieties is unknown. Five sorts are grown about Mandalay.

Phaseolus aconitifolius is the moth bean of the Orient.

Phaseolus angularis is the famous adzuki of Japan and the east coast of Asia.

Tephrosia candida is usually regarded only as a green-manure and windbelt crop, but De Sornay claims that the seeds "are largely used in Reunion for feeding cows and pigs." The proteid-content of these small seeds is very high, some 32 per cent. While this rapid-growing legume shrub cannot, it seems, safely be used as a forage, it is without doubt one of the best means for furnishing nitrogen to other crops. It endures pruning back well. It stands 8 feet. The leaves are supposed to contain some poisonous principle. Several other species are used to stupefy fish, and probably an insecticide can be prepared from it.

The broad bean, *Vicia Faba,* is generally believed to be an old temperate zone bean, but it is now grown at slight elevations in Java, Arabia, Egypt, north Africa down to the Sudan, and Madagascar. This large coarse bean has a strong taste. A flour is made from the decorticated seeds. The proteid-content is nearly 25 per cent.

The sword, jack, horse, or canavali beans, *Canavalia ensiformis* and *C. gladiata,* are coarse semi-bushy plants native to India. The unripe seeds and very young pods (4

to 6 inches) may be used for human food. The outer coat must be removed, by soaking over night and then rubbing, before the dry seeds are safe for the table. There are three kinds, with white, pink, and red seeds. Authorities differ as to the value of these beans as forage; but there is no question but that the unripe seeds and the cooked ripe seeds are an excellent grain. The yield of seeds in Hawaii runs to some 1,200 pounds to the acre, and the green forage from 15 to 18 tons to the acre. Primarily the horse beans are green-manures especially adapted to cane, citrus, and rubber plantations. They should be bred up so that there will be no fear of using both seeds and tops for forage.

Three important leguminous trees bear edible pods of value in stock-feeding. The mesquite or algaroba, Prosopis species, is native to Mexico and Central America. It has become very popular in Hawaii where at present over 50,000 acres are in this quick-growing drought-resisting legume. It attains 30 feet or more. The pods are very nutritious and greatly relished by horses, cattle, and pigs; the pulp surrounding the seeds is over half sugar. The Hawaiian crop is worth about $500,000 yearly. The dry pods are ground into a coarse meal for feed. This tree seems to vary in habit, according to locality. It is being tried out in many countries.

The carob, *Ceratonia Siliqua,* of North Africa, Spain, Arabia, and the Levant bears larger and coarser pods than the algaroba. The pulp is consumed by the poorer classes and, either whole or ground, the pods are an excellent stock-feed. It is behaving well now in South Africa and Australia.

The samans or guangos, Samanea species, are tropical American trees of great size. The black curved pods are full of a very sweet pulp which is an excellent stock-feed. The pods do not store well, unfortunately, and cannot be ground like the algaroba and carob pods. In the West Indies the guango is planted in Guinea-grass pastures very successfully.

Fenugreek, *Trigonella Fœnum-Græcum,* is an alfalfa-like

legume of south Asia and northeast Africa. In Abyssinia it is cultivated for fodder. The ill-smelling seed is very fattening, about 22 per cent protein.

Alfalfa or lucerne, *Medicago sativa,* is a crop of very wide distribution and of apparently multiple origin. Many tropical countries grow it for forage. At the famous Poona Agricultural Experiment Station in India 38 tons of green fodder were removed from one acre. It does not like sea-level in the tropics; there it should be replaced with pigeon pea or perhaps Hubam clover.

Leucœna glauca is a leguminous shrub of very wide distribution in the tropics. The original habitat seems to be unknown. It grows very rapidly and stands some topping. Goats do very well on it and cattle browse it; but if fed to horses or swine it has a pronounced depilatory action.

Berseem, *Trifolium alexandrinum,* is one of the few tropical clovers. While it is the principal green feed for camels, asses, horses, and cattle in Egypt, it has never done very well in other countries, unfortunately.

Tropical planters are hoping that the new Hubam clover, *Melilōtus alba* var. *annua,* will hold true. This annual race of the old Bokhara or white sweet clover grows very rapidly to a height of 6 or 8 feet and makes a dense stand of fragrant highly nutritious forage. It is too rich to be fed alone. Soil inoculation seems to help it at the start. It may prove to be one of the best tropical substitutes for alfalfa.

MISCELLANEOUS GRAINS

One of the best tropical grains is sesame or til, *Sesamum orientale,* of the small family Pedaliaceæ. This coarse erect woody herb is of unknown origin, probably south Asiatic, and is now grown in most countries of the tropics. In Spanish America it is known as ajonjolí. India is the principal producing country; Macmillan states there are 4,500,000 acres there.

PLATE XXI.—Transporting heavy bundles of abacá fiber over rough trail, Albay, Philippine Islands.

The plant reaches 3 to 8 feet in height. The crop period is about four months. When the two-celled capsules are nearly ripe the plants are cut near the ground, tied in bundles and when the capsules are dry they open and then the bundles are turned bottom up so that the small seeds pour out without threshing.

Ordinary extraction methods give about 40 per cent of a clear bland oil fit for any food purpose; it keeps exceedingly well. Commercially this oil is more important than olive oil. The cake is one of the best stock feeds; the seeds are practically hull-less.

There are many varieties. The seeds usually are nearly white, but there are black, red, and yellow sorts. Even in poor sandy soil in dry weather sesame thrives luxuriantly. Like the asparagus pea, Psophocarpus, and the pigeon pea, sesame holds promise of a great food crop of the future, but to date no real effort has ever been made to study the varieties nor the good and bad qualities of this grain. Some 300,000 tons, probably half of the total crop, goes into trade, valued at $30,000,000.

Another oil grain of much importance, but one that is usually overlooked in lists of the great crops, is rapeseed. This crop is very extensively cultivated in British India and China, and much of the grain is used locally; but some 225,000 tons or more goes overseas, worth about $18,000,000 or $20,000,000. Colza and mustard are very similar oil grains, widely grown.

Niger-seed or black til, *Guizotia abyssinica,* is still another composite oil-seed, probably African in origin, but now cultivated principally in India. Enormous quantities are used locally and some thousands of tons go to Europe; but, since there is a deplorable dearth of accurate knowledge concerning oil-seeds in commercial circles, this material is usually included in the "n.e.s." or "all other" lists of imported seed stuffs. It is used for cooking, lighting, and soap-making.

FORAGE PLANTS

The best cultivated grass for the tropics is unquestionably Guinea, *Panicum maximum,* of tropical Africa. It has three prime virtues: it grows luxuriantly; it is very rich in sugars and proteids; it has no hard fibers even when standing 12 feet high. It is a quick and semi-perennial forage, very fattening, and having no waste culms. This grass was brought to the Antilles in the first slave ships from the West Coast of Africa early in the sixteenth century.

This grass is nearly always propagated by division of the root-clumps, a handful of the stem-bases to a hill, the hills about 3 feet apart. During the Great War many tons of seed were imported from Colombia to the Canal Zone for the emergency pastures. In good soil with no weeds nor drought, Guinea may be cut every four to eight weeks; 20 to 30 tons is probably average, but yields of 80 to 100 tons have been reported in Hongkong.

Guinea is remarkably non-variable. Without this grass stock-feeding in the tropics would be precarious. It dries readily and when ground to a coarse meal it can be kept and shipped safely.

Pará-grass or malojillo, *Panicum barbinode,* of South America is the second best forage in the western hemisphere. It is now becoming popular in the Orient. Pará is a wet-land grass and will not succeed in the dry soils which Guinea likes. Like Guinea it is a poor seeder. Cuttings of the stems are stuck into the mud or, in the dry season, plowed in, the joints laid in the furrow ahead of the plow so as to be half covered. Pará is more cheaply grown than Guinea and it can be put on ground too wet for other crops.

Elephant-grass, *Pennisetum purpureum,* is rapidly winning much favor in tropical America. This Uganda grass in good soil attains a height of 10 or 12 feet in three to four months. The stems are so coarse that, unless run through a forage cutter, there is considerable waste. Elephant rattoons

well and may be cut repeatedly. It is not particular as to soil and endures drought well. It is one of the great forage grasses of the future; it does not pasture well, but is ideal for dairy cattle (Plate V).

Guatemala-grass, *Tripsacum laxum,* is a lush giant forage of recent entrance into the field of agronomy. It is one of the heaviest producers known where soil and rain are favorable, but it cannot endure drought and does not do well in poor or shallow soils. With its broad dark green leaves and very thick, but fairly tender, stem it resembles young sugar-cane. Propagation is by "roots," *i.e.,* the bases of the suckers in the old clump. Cuttings may be taken every month or two for two to four years. Guatemala is a most valuable stable feed; run through the cutter, it is eaten with little wastage; for pastures it is useless. In wet localities and in deep soil this grass ranks a little ahead, perhaps, of both elephant and Pará. Within a decade it should be common even in the Orient.

Molasses-grass, *Melinis minutiflora,* is a good pasture grass for cool regions in the tropics. It is probably South African in origin, but may be Brazilian. Above 2,500 feet elevation it is the principal pasturage in Colombia. Although it grows well enough, 3 to 4 feet, at sea-level, it stands grazing only in the high lands. In full sunlight this grass gives off an effluvium like hot cane sirup. The leaves and stems are covered with a sticky pubescence which is reputed to kill ticks. Molasses makes an excellent hay, yielding about 5 tons to the acre. The analysis indicates a very high content of protein, 7.5 per cent.

Bermuda-grass, *Cynodon Dactylon,* covers more acres of ground than any other "tame" grass in the tropics. One of the smallest forage species, it is necessarily not a heavy yielder, 10 to 20 tons to the acre, but for covering bare ground—even gravel—there is no rival. It stands grazing better than would be expected for a creeping light-rooting grass. There are several varieties. Vigorous plants will shoot 10-foot runners over the hottest driest ground in a

few weeks. Bermuda makes a good hay. Propagation is by chopped-up runners or seed.

Sudan-grass, *Holcus sudanensis,* is highly regarded in South Africa and a few other localities. It has not become so popular as was expected when it first made its appearance in the New World. It grows 5 to 11 feet high and resists drought. Its stems are coarse but relished by cattle and horses. The very similar Johnson-grass, *Holcus halepensis,* is grown in India, Australia, and South America; it is feared for its deep rhizomes which render it practically ineradicable.

Japanese cane, *Saccharum spontaneum,* has been grown for years in the Philippines and tropical America as a cattle forage. Under proper management it may excel all other fodder plants in amount of green feed to the acre, but it is a difficult species to handle or propagate. It may stand anywhere from 10 to 20 feet high in fair soil, the diameter of the stalks being rather less than 1 inch. It appears to vary somewhat, or else there are several forms. As a cheap filler of silos in the tropics, it will probably surpass everything but maize and some of the kafirs.

Rhodes-grass, *Chloris Gayana,* is hardly heavy enough for the intensive demands of tropical dairies and "pens." It is from South Africa and, naturally, quite drought-resistant. It stands 2 to 4 feet in fair soil. Young plants throw out long stolons, 6 or 8 feet, and spread rapidly. Several seasons may pass before it requires replanting.

Napier-grass, *Pennisetum glaucum,* is a tall, 8 to 10 feet, coarse forage, rather popular in India, and drought-resistant.

Teosinte, *Euchlæna mexicana,* is a very interesting forage plant native to Central America. It has been praised and censured as a crop. It may seed at 3 feet or run up to 10. A great number of suckers spring from the old clump, and these may be cut several times; 20-ton single cuttings have been recorded. Teosinte hybridizes with maize. The large seeds are borne in a husk, without a cob.

Teff, *Eragrostis abyssinica,* is a fairly common tropical African forage and grain crop. In northeast Africa the seed is made into bread.

Kikuya-grass, *Pennisetum clandestinum,* is related to the giant elephant-grass, but it has quite the opposite appearance. It creeps along the ground, rooting at the nodes, and seldom reaching even medium height. It appears to be quite nutritious, but outside of South Africa it is not very popular.

The three best indigenous grasses of the Philippines are: balili, *Panicum stagninum,* a little-known forage which should be grown elsewhere; the official figures for the yield are 81,572 kilos a hectare (about 37 tons an acre); bungalon, *Homalocenchrus hexandrus,* a rare grass of high productivity, no waste in feeding; barit, listed as *Leersia hexandra* but probably a synonym of the previous species, is the wetland forage grown about towns for feeding the domesticated animals; so tender that there are no "orts" left in feeding.

In Central America (their home), South Africa, North Africa, Australia, and parts of South America various species of Opuntia have taken possession of vast areas of land. Some species are very nearly spineless but most of them are so covered (both "slabs," or "pencas," and fruits) with short spines that live-stock will eat the juicy and fairly nutritious pulp only when driven by thirst or hunger.

According to Wilcox,[1] the spine becomes "flexible and leathery" when the slabs, mixed with wild grasses, are made into ensilage. If this idea becomes practicable—if silos in countries like Queensland can be filled and successfully operated so that the material can be used as a cattle feed—it will be another great triumph for modern agronomy.

In Australia it is estimated that a million acres of land—practically waste, to be sure—are lost yearly by this weed (*O. Dillenii*); in the eastern part of that continent there are already 60,000,000 acres ruined. The so-called spineless varieties usually revert to spininess at the least provo-

[1] Wilcox, E. V., "Tropical Agriculture," 1924.

cation. Much valuable ground has been planted up with various nearly spineless opuntia which were expected to furnish large amounts of luscious forage and delicious fruits. The writer has seen only two individual mature plants which appeared to be absolutely without spines, specimens of the Semaphore cactus, *O. rubescens*, one in St. Thomas and one in Porto Rico.

In Ceylon, Hawaii, and Porto Rico several species of spiderwort, Commelina, and closely related plants are used as forage for swine and cattle. Although exceedingly watery, the yield to the acre may run very high. Wilcox states that the Hawaiian honohono in one test gave "200 tons of green material per acre" in twelve cuttings. The record yield for a grass (Pará) is said to be 118 tons.

Another neglected branch of the forage subject is tree foliage. The breadfruit is perhaps one of the great forage plants of the future. The large leaves are full of a creamy latex and when dried and beaten or ground into a coarse meal they make an excellent fodder.[1] Fresh they are relished by most animals from elephants to asses.

Ramoon, or ramon, is the name given to several species of Trophis and Brosimum. The small branches and leaves are fed, usually fresh, to horses and cattle. Leaves of spineless species of Erythrina are also used. Australia, South Africa, and India have a number of species of forage trees which are drawn on in times of drought to eke out the livestock rations.

[1] One analysis showed a protein-content of over 24 per cent, which compares well with cowpea-leaf hay, 18.8 to 22.4 per cent.

CHAPTER XIX

THE ROOT-CROPS

WITHOUT these humble food providers the tropics would be practically uninhabited. They are cheap, available throughout the year, cultivable in almost any soil. The Masai of Tanganyika can exist on meat, blood and milk; some Congo tribes get along on bats and bananas; in Cochin-China a coolie can work on a 95 per cent rice diet. Most dwellers in the tropics of both hemispheres rely to a great extent on the four main root-crops—sweet potatoes, cassava, yams, and taros. These indispensable foods are not in the lime-light: some, like cassava, are seldom carried to the market. They are simply in every garden patch, "shamba," and field corner.

SWEET POTATO

If the potato is king, then the queen of all root-crops is the old camote or batata, *Ipomœa Batatas,* of tropical America. Unfortunately its name in the Antilles when Colón arrived, batata or patata, was given to the South American pappas or papa, *Solanum tuberosum,* now passing under the name of Irish, or white, potato. Both these crops from the New World colonies arrived in Spain early in the sixteenth century. Papa is still the word for Irish potato in Spanish-speaking countries; but the English, to distinguish the batata from what they called the potato, prefixed sweet. It is a vine of the Convolvulaceæ, or Morning-Glory family.

On the stupendous megalithic terraces of Ollantaytambo some pre-Inca farmer tested the wild plant which sometimes had thickened starchy roots that he had proved to

be eatable; 3000 B.C., or thereabouts, presumably. When the conquistadores came they found the Incas had several sorts of these camotes and they distinguished the dry type, the cumara, from the wet usually sweeter type, the apichu.

The Arawaks apparently had only just received the batata, as they called it, from the south mainland when the Spaniards arrived; when it reached the Aztecs, or perhaps, Toltecs (as the camote) is not known. According to a semi-legendary account this great crop was taken across the Pacific to New Zealand long before that country was discovered; and the arrival of the "cumara" was the first great event in Maori oral history. It reached the Orient through Spanish hands and immediately took a prominent place in the domestic economy of the Philippines, then India and China.

There are probably 200 or more varieties now under cultivation in the Americas, Asia, and Africa. Besides the two great divisions of types, the drys and wets, there are varieties which have very long slender roots with reddish or purplish feculas,[1] and of course plenty of connecting links. A few years ago a plant from Haiti bore both purple- and yellow-skinned roots. In the last decade J. B. Thompson in St. Croix and others in Cuba and the Philippines have raised hundreds of seedlings, mostly hybrids. While most of the new sorts are inferior in productiveness, a fair proportion seems worthy of attention. Some showed strange combinations of fecula colors; one, named by the author "Thompson's Star," has purple bands radiating surfaceward in a pale yellow fecula.

Some varieties are so dry and floury when cooked that they need coconut oil or some sort of fat to be eaten easily. The "ahoga-perro" (dog choker) of Porto Rico is an example. Others are mushy and very sweet.

[1] It seems best to take over the Spanish word fécula, meaning the starchy solid inner portion of roots, tubers, and dry fruits, on a par with pulp of wet fruits.

A strange and very rare variety with nearly black leaves was found in Porto Rico in 1924. It is probably a sport. There are several bush forms.

There are three methods of propagation, though only one is generally used. Vine cuttings, 1 to 2 feet or more long, taken from the older growth, are set into shallow hills or ridges or on the flat ground, one or both ends of the cutting left outside to breathe and the remainder lightly covered. Stripped of leaves and stuffed into a sack, or rolled up in banana leaves, these wilted but quite viable cuttings may travel for days, half baked by the sun, borne on the head of a Bantu savage in the Sudan or on a patient plodding burro in the western tropics. Kicked into the unplowed ground, seldom hoed or weeded, the sweet potato takes care of itself.

The roots may be sprouted by covering them with trash or sand, and these sprouts may be transplanted into hills in the field when they show a few small leaves. This is the approved method in the United States. Hotbed forcing is often resorted to. In dry soil entire, or portions of, dry roots may be planted like potato tubers.

The seeds are seldom seen except by horticulturists in the tropics, although the pink or purplish morning-glory-like flowers are common enough in those regions but not often appearing in the commercial fields in the United States. These seeds do not come true. Theoretically volunteer seedlings may occur in any field in hot dry regions; new varieties may start spontaneously in this manner. Hybridizers have here a great field.

The yield from the common field of sweet potatoes is pitiably light, perhaps a ton or two to the acre each year. The average tropical field is probably less than one-tenth acre. First-class varieties, like the famous Key West, can turn out 15 tons. If high-yielding camote varieties were grown throughout the tropics in place of the wretched sorts in evidence, the high death-rate would be lowered, the birth-rate increased, and kitchen-garden space economized—a

more important matter than most students of rural food-supply problems realize.

A very severe insect pest of sweet potato, *Cylas formicarius,* is spreading over the world. It attacks the roots, the larval galleries rendering them unfit for table use. Fumigation of the vine cuttings, where the eggs are laid, is quite effective if thoroughly done. Another weevil is much less serious.

Several rusts and blights attack the leaves and various fungi rot the roots in storage.

A sirup has been manufactured commercially from the ripe roots which may contain from 20 to 25 per cent of carbohydrates, starch and sugar. The calories run about 570 to the pound as against 385 or so for the white potato. A very wholesome flour, of excellent keeping qualities, is made from the dried sliced roots. Starch extraction is difficult. Dehydrated diced or sliced roots are good food material and keep well if protected from moisture. Large quantities are canned in United States; the total crop there is around 60,000,000 bushels. In Australia it is proposed to use the roots as a source of alcohol.

The tips of the vine runners can be used as a spinach substitute. A species is semi-cultivated in Luzon for greens. *Ipomœa tiliacea,* which might have been the original that the pre-Inca race domesticated, since it, also, occasionally bears swollen roots, is an excellent pig feed in the Antilles, just as a similar species is relished by the pigmy hippopotamus in Liberia. Sweet-potato hay is a theoretical but hardy practical fodder; the rich latex in the leaves and stems evaporates slowly. Fresh vines are excellent for all live-stock.

CASSAVA

The cassavas are possibly cultigens, though apparently naturalized in the very dry parts of northeastern Brazil. The family, Euphorbiaceæ, is full of suspicious species, and both the so-called bitter and sweet types of cassava are

believed to cause sudden death under certain circumstances. Both types belong to *Manihot esculenta.* The roots of either type at a certain stage may contain a small amount of a certain substance which, when partly cooked and allowed to start fermenting, may release hydrocyanic acid; yet the fresh raw and the roasted or boiled roots usually may be eaten with impunity.

Yuca was probably the old Carib name, but in Haiti the Arawaks called it "kasabi," from which followed the Spanish casabe and thence the English cassava. Venezuela and Colombia are the native home of all the 50 to 75 or more distinct sorts. The Incas knew it as "rumu." The Spaniards said the South American name was "manihot," but mandioca or manioc is the correct word.

In many parts of South and Central America, yuca in some form is eaten by all classes of society, twice a day, and for nearly every day in the year. The Amerinds had ages ago learned how to grate the roots and dry or bake the mass in thin cakes. They also stored the coarse meal in large earthen ollas, and in the off-season they ate this as a gruel, tapioca soup, or baked it in kasabi cakes. A very intoxicating beverage is prepared in Colombia and the neighboring regions from the fermented grated or chewed root. Though not generally known, yuca is now a staple food on both the east and west coast of Africa.

The juice expressed from the grated root forms the basis of some of the best table sauces, as cassareep which enters into the famous West Indian "pepper-pot" as the subtle principle which keeps the meats from decay; for years the pot may never be emptied and a mouthful of its very piquant contents taken at the end of a hearty meal prevents indigestion.

For several decades both British and Dutch Malaya have furnished the bulk of the world's cassava flour for the manufacture of tapioca. There are three ways of handling this starch. Both the "pearl" pellets and "flake" tapioca are still imported, but many thousand tons come

into United States now in the form of a 99 per cent pure dry starch. Brazil exports large quantities of mandioca meal, usually rather coarse and not very pure. The farm production is reported as 3,000,000 tons. Madagascar ships some crude stuff, the roots merely crushed and dried whole.

In Liberia yuca is prepared in a unique way for the table. The roots are peeled, partially boiled, then pounded in a wooden mortar till a very stiff dough is formed (the longer the heavy pestle beats the mass the better the paste texture). It is allowed to "rest" for some hours and is then put into a large kettle and again partly cooked, but not enough to break the remarkable tenacity of the mass. It is then eaten, usually with capsicum sauce or meat broth, the huge mouthfuls being swallowed without chewing. This is the famous "dumboi."

There is hardly a more wholesome food. The starch grain is of medium size; it is unique in having a stellate hilum.

Yuca vies with the camote as being the easiest crop to propagate. Stem-cuttings 8 to 10 inches long are set into flat hills about 4 to 6 feet apart, two-thirds of their length in the soil. About 90 per cent germination is usual. Long pieces of the stems, stripped of leaves and small branches, will keep, in a dry place in the shade, for several months. If the papery cuticle remains intact, these stem-cuttings can be carried around the world.

By the end of six months some small early varieties may be harvested. Some of the so-called bitter sorts, which reach a height of 6 or even 10 feet, may require about a year to mature. Occasionally plants are left over into the second season; these may bear roots weighing 15 to 25 pounds or more. Flat cultivation is the rule. From 1,000 to 2,000 hills to the acre, depending on variety and soil, is the usual spacing.

The average yield a hill, usually of two main stems, is around 2 to 5 pounds, 2 to 5 or even 10 tons an acre in good

locations. The starch-content varies from 10 to over 36 per cent, according to the variety. The Saracura variety of Brazil is said to contain 36.69 per cent starch. About 25 per cent is normal.

Yuca has few serious pests. A bud maggot, *Lonchæa chalybea,* is common but not very dangerous in tropical America. Hand-picking the tender tips of the branches is the logical control method. A Sphingid caterpillar is sometimes rather troublesome; again, hand-picking is recommended.

Root-rots are rare and leaf-blights not common.

There are hundreds of thousands of acres of cheap dry land in both tropics wherein cassava can be grown very cheaply. Enormous quantities of one of the world's cheapest foodstuffs could be shipped out of the tropics if and when demand arises. It is, or will be, one of the cheapest sources of alcohol, dextrin, and glucose.

The estimated world crop is 7,000,000 tons of roots; Brazil, Venezuela, and Colombia produce over half of the total. At ¾ of a cent a pound the value is over $100,000,000.

YAMS [1]

Yams are the third most important group of tropical root-crops. Scarcely any other group is so difficult to the taxonomist, largely because they so seldom flower, some varieties probably never. These vines hold absolutely true to type and there seem to be remarkably few sports. Some are cultigens, in India and tropical America; some are indigens seldom cultivated. Most of the species contain a poisonous principle, in some cases ordinary cooking being hardly sufficiently safe.

A few decades ago there were supposed to be only some twenty-five kinds; now Burkill, after twenty years study, finds scores. Nearly all true yams belong to the genus

[1] Kinman, C. F., "Yam Culture in Porto Rico," Porto Rico Agr. Exp. Sta., Bull. 27, 1921.

Dioscorea of the Dioscoreaceæ. The Smilax and Lily families are related.

In some localities of the United States certain types, either wets or drys, of sweet potatoes are erroneously called yams.

Yams are particular as to soil and drainage, but they endure droughts better perhaps than any other root-crop. Depth they must have; hence many fields are ridged or mounded, so that the long, often cylindrical, thick roots can have room to grow downward without lifting the plant. The layered-trench system consists of a ditch about 2 feet deep filled with layers of trash and earth well tramped, and the sets are planted in the high ridge of loose earth over the trench, thus allowing the roots nearly 3 feet for their extension.

The base of one of the old stems with a few inches of the root attached is the best propagating material. Chunks of the root, the nearer the stem the better, will usually sprout except in wet weather. Each hill thus furnishes only four to six good sets for planting the next crop.

Rows may be 4 to 5 feet apart, the plants 2 or 3 feet apart in the row. The little mapuey yam of Porto Rico requires no support. The Guinea prefers a tripod or bamboo fence. Some of the rampant water yams will quickly ascend to the top of a good-sized tree and return to the ground.

Some of the most delicious yampee, or cush-cush, yams of the Antilles may yield barely 3 pounds a hill, while some water yams may give 50 pounds or more.

India and Ceylon have a large globular-rooted species, very rare elsewhere. The Guinea yam may have been carried around from India to the west coast of Africa. It was the principal food on the slave ships and was undoubtedly brought into the Antilles with the Guinea-grass and the "guineos," or bananas, before the seventeenth century. There are probably thirty or more distinct sorts of the water yams, *D. alata*, distinguished by their winged stems; fecula colors range from snow-white through yellows and

oranges to beautiful purples. The mapuey morado, *D. trifida,* has perhaps the darkest fecula known—a purplish-black. The potato yam, *D. esculenta,* is one of the many excellent varieties of "tongo" native to Malaya; some sorts resemble potatoes; some are sweet. The yield runs to 8 or 10 tons an acre. The air potato or gunda, *D. pilosiuscula,* bears sizable axillary tubers in the leaf-axils; they may be kept a year. There are several wild species in the Philippine Islands, and the semi-civilized natives of the jungles are accustomed to cut the roots in pieces and immerse them in running water for a few days before attempting to cook them. One Philippine species gives off the strong fragrance of fresh raspberries while cooking. Wild species occur in both the West and East Indies; several merit domestication.

Yams may be cooked like potatoes but are best baked in the rind, which is also edible. Flour made by grinding the dried, raw or cooked, slices is a wholesome commodity but rather too expensive for export.

Starch cannot be made from yams because the mucilaginous gum prevents the grains from settling.

The yams are primarily a minor crop, yet millions in Asia, Africa, and the Americas greatly relish them.

TARO

The taros and dasheens of the Orient are next in importance, probably a little ahead of the very ancient yautías of tropical America.

The colocasias are the only important group of edible aroids. The number of distinct varieties in Polynesia, Malaysia and south China may run to over 300, of which 50 are readily distinguishable by the layman. These and the similar dasheens with their tuber-like offsets or cormels, are all stemless large-leaved plants standing, in good moist soil, 4 to 6 feet high.

The propagation is easy; a few inches of the top of the corm is "seed." The yield is high. The wholesomeness of

the starchy rhizomes, or corms, is extra good; the very minute size of the starch grain is probably the main reason for the very high digestibility of their fecula. The starch-content runs from about 8 per cent to over 15 per cent in the fresh root.

The taros have been cultivated so long that many of them never flower and it is probable that no civilized man ever saw a viable taro seed.

Throughout Polynesia this crop was, with the breadfruit, the principal food of the natives. They invented a special method of preparing the corms. Like the dumboi of Liberia, the poi of the Pacific archipelagoes is a pasty mass which requires no chewing; but poi is fermented much more than dumboi and is thinner, in fact, there are one-, two-, and three-finger pois, the thicker varieties being eaten from one or two fingers dipped into the family bowl. Good poi has a faintly sour taste but is very palatable and very easily digested. The purplish taros make the best poi. The paste or purée is also made into cakes and baked or toasted, with delicious flavor. In the Kanaka language of the poi eaters there is no word for indigestion.

Some taros prefer mud or very wet soil, some endure ordinary alluvium. The tuber-bearing type, the dasheens, will yield fairly well in rather dry land. The larger taros require eight to twelve months or more to mature the rhizome. Most dasheens give ripe cormels in six to eight months and one, the thunmas-ala of Ceylon, is reputed to mature in three months, perhaps the shortest season of any root-crop. The acre yield varies greatly, according to variety. One of the purple-rooted taros of Hawaii—said to be formerly grown only for the royal family—may give only a few hundredweight, while the Penang and Trinidad dasheens should yield as many tons. Wilcox puts the acre output, in Hawaii, at 6 to 18 tons, and the time at eight to fourteen months.

The dasheens should be lifted—with pick or spade or

lever-stick—soon after the leaves show (yellowing) that the offsets, or cormels, are full. If left much longer the latter may start to sprout and become watery. Both the central corms and the side cormels are equally good eating in the case of the dasheens. Most taros never produce edible side cormels. The corms and cormels keep in dry storage very well after digging and topping, cutting off the leaf-bases a few inches above the root. They ship well if kept dry.

The young central leaf-bud, before it unrolls, is frequently cooked like spinach. A Japanese variety has been grown so long for that purpose that the leaves may be eaten raw as salad. The leaves of most aroids, however, are full of the mechanically poisonous raphides of calcium oxalate; likewise the raw roots.

A flour made from the boiled and dried corms of Hawaiian taro has been on the market as an invalid food. Considering its very remarkable digestibility and cheapness, it seems strange that it is not a very common foodstuff. An excellent breakfast food can be prepared by shredding the raw root, then steaming and drying.

Taro, or talo, is, of course, the ancient native name. Dasheen, or dachine, as the best known variety of the tuber-type is called in Trinidad, is the garbled spelling of de la (da) Chine. How that variety happened to reach the West Indies from the Far East, China perhaps, no one knows now. Another very inferior variety, neither a true taro nor a dasheen, has become naturalized up in the almost uninhabited mountainous interior of Dominica. A third variety, a genuine large taro, is common throughout the Antilles, probably brought over from the Guinea Coast with the slaves.

A rather serious root-rot, probably a fungus agent, attacks the corms. Very careful selection of the seed plants is the remedy. Lime applied to attacked corms in storage helps check the disease.

YAUTÍAS (PLATE XXIV)

The yautías, or taniers, are perhaps the least known yet possibly the very oldest group of root-crops in cultivation. They are all strictly American. They belong to the same sub-family as the taros, but have sagittate instead of peltate leaves. Some have cormels, usually of good size, oblong or obovate-cylindrical, some only leafy offsets. There are some thirty-nine species and about twenty botanically distinct varieties of the genus Xanthosoma. They stand rather larger than the taros; some cultivated varieties in good soil reach 7 or 8 feet to the top blade.

These very interesting plants were almost certainly developed locally. The Antilles seem to have more indigenous varieties than any of the mainland countries of Central or northern South America. In a survey made by the author,[1] 1902 to 1908, Porto Rico had about twice as many local varieties as any other country, some fourteen, of which six were commonly grown all over the island.

Many varieties seldom flower; none of the cultivated ones ever sets seed. The calla-like flowers, the spathe 6 to 12 inches long, are malacophilous, though snails are very seldom seen in them.

Several varieties have the petiole and blade veins a dark maroon-purple color; the petioles of others show stripes and blotches of several shades, yellow, white, purplish, or brownish. Some have been grown as ornamentals under various horticultural names in different countries for many years. A few varieties are in evidence in the East Indies; one in Fernando Po and the Philippines was probably carried thither by the Spaniards.

The cormel fecula varies from white through yellow and orange to pinkish and dark purple. Some cormels cook up soft, others always remain very firm. They are about twice as nutritious as the Irish potato and their starch grain

[1] Barrett, O. W., "The Yautías, or Taniers, of Porto Rico," Porto Rico Agr. Exp. Sta., Bull. 6, 1905.

PLATE XXII.—*Left:* abacá fiber-stripping apparatus. *Right:* bleaching abacá fiber, Philippine Islands.

is of medium size, not so readily digested as the taros but very wholesome. The calories run about 535 to the pound, as against 570 for the camote, or sweet potato, and 385 for the white potato.

The unrolling center leaf is cooked for greens, like the taro bud. In some of the Antilles they enter largely into the famous "calalu" stews, or thick, spiced, very rich soups.

In the Arawak idiom ya indicated locality, or place where; hutia still is the name of the large rodent, Capromys, which is fond of roots as well as fruits.

From eastern Mexico down to central Brazil there are probably numerous kinds of economic xanthosomas, some of which have hardly been observed yet by anyone who could recognize what they were. The author attempted to classify the known varieties in 1908;[1] unfortunately this work has never been completed.

A flour is on the market made from the Rolliza, or Blanca, yautía (*X. Caracu*) cormels; it is recommended by physicians in cases of sprue where ordinary starchy foods are forbidden.

A leaf-blight and a root-rot attack yautías, also an aphis, and sometimes a mealy-bug. The yautías, however, are unusually free from pests and diseases.

Yautías are easily propagated by a piece of the old central rhizome or a small cormel set some 3 or 4 feet apart. They are easily harvested and the cormels store well if kept dry. The larger cormels, barely covered by the soil, may be removed without disturbing the mother plant which then throws more sap into the smaller offsets and thus the total yield is very probably increased by the so-called castration method.

The ape, *Alocasia macrorhiza,* is a coarse-looking aroid, producing a large rhizome above ground, which is a common pig feed in some tropical regions.

[1] Barrett, O. W., and Cook, O. F., "Promising Root Crops for the South," U. S. Dept. Agr., Bur. Plant Ind. Bull. 164, 1910.

CANNA

The edible canna, or tou-les-mois, is an old American species, *Canna edulis,* of some importance. It belongs to the Cannaceæ, near the bananas. In rich moist soils few starch crops can surpass it in weight of yield of roots; a gross yield at the rate of about 15 tons an acre has been obtained.

On account of the coarse fibers in the short-cylindrical or oblong rhizome at the base of each offshoot stem, this root is not fit for the table. Grated and washed, however, the starch settles quickly to the bottom of the vat or container. The starch-content is about 24 per cent. The grains of canna starch are among the largest known, some 100 times larger than those of the taro; if used in laundry work this starch breaks the cloth.

The old Spanish (West Indian) name was maraca; the Arawaks, who probably made some attempt at cultivating it, called it imocona. The exact place of origin is unknown, but evidence points to Peru, where the old Quichua name was achira. This imocona is probably the largest canna; it usually stands 6 or 8 feet high but may grow nearly double that. There appears to be only one variety known. The separated rootstocks keep and germinate extra well.

Canna is attracting some attention of late in Hawaii as a cheap source of starch. The plants endure crowding well. They relish humus and heavy manuring. About ten to twelve months are required to mature the roots. Wherever there is a demand for a cheap coarse starch, and a supply of moist land, this crop can be depended on.

The rootstocks seem to be immune, but a butterfly leaf-roller sometimes injures the young leaves.

ARROWROOT

The old cauallo of the Arawaks, or West Indian arrowroot, *Maranta arundinacea,* was called maranta by the first Antillean settlers. It belongs to the small family Marantaceæ. In Bermuda, St. Vincent, and a few other places

it was formerly cultivated rather extensively. Two things set it back, the discovery that the continued use of arrowroot starch causes an intestinal trouble, and the competition of cassava flour.

The peculiar specialized eye-less rhizomes, about 4 to 8 inches long, thickening toward the tip, are so full of coarse fibers that they can hardly be eaten. Starch is very easily extracted from them since they have no colored envelope and are very brittle. The percentage of starch is rather less than 20. Three to 5 tons of roots to the acre are a good yield.

The Indian arrowroot, or tacca, *Tacca pinnatifida,* belongs to the obscure family, Taccaceæ. It is little known in commerce but there are few root-crops of wider cultivation or with more names. From Hawaii and Tahiti to Mozambique, and from China to Bombay it is a fairly common small-farm crop. The writer has found it apparently wild, at least naturalized, in East Africa. Perhaps it is a cultigen as the original habitat is quite unknown. It is a stemless aroid-like plant growing from 2 to 3 feet high.

The pia, as it is commoniy called in Polynesia, has a fine large roundish corm full of a white starchy fecula and an acrid bitter principle, which must be eliminated carefully, by grating and soaking, before it can be used for a sago. The young leaves are also eaten.

The pia has many good characters, but for some reason it has never held the attention of a modern agronomist. By up-breeding its acridness might be eliminated.

MISCELLANEOUS ROOT-CROPS

The leren or topi-tambou, *Calathea Allouia,* was semi-cultivated by the Caribs of South America and the Arawaks of the West Indies long before the Spaniards arrived there. It belongs to the Marantaceæ and somewhat resembles the arrowroot. It grows about 2 to 4 feet high. Flowers are produced under favorable conditions, but no seed. The ovoid tubers are eye-less; the fibrous rootstocks, 6 to 12

to a hill, are used for propagation. These yellow-skinned tubers, 1 to 2 inches long, are quite fiberless; the central portion is translucent; boiled, the flavor is distinctly that of sweet-corn and the odor while cooking is delightful. This is one of the slowest-maturing crops, twelve to fifteen months being required. Its keeping qualities, in or out of the ground, are excellent. It prefers partial shade and moist soil—adapted to the margins of mountain streams—but will grow almost anywhere.

The palauan, *Cyrtosperma Merkusii,* of the central Philippine Islands, is scarcely known outside of that archipelago. It is one of the largest aroids. Its coarse starchy rhizome is a load for a man. Its huge yautía-like leaves stand 8 to 12 feet or more above the mud of the swamps where it likes to grow. The more or less cylindrical rootstock in old (two to four years) plants may extend 3 or 4 feet out of and half as much, perhaps, below ground. The yield from an acre of swamp, semi-cultivated, might run to many tons.

The oroy, *Amorphophallus campanulatus,* also of the Philippines, is another interesting aroid semi-cultivated for its enormous lozenge-shaped corm. The multifid leaf-blade tops the 4- to 6-foot vertical petiole, which is blotched and spotted with many shades of brown, purple, pink, and green. The flower is one of the largest after the rafflesias; the purplish-blotched spathe may measure 2 or 3 feet in diameter, and the hideous-appearing spadix is nearly as long. The corm may weigh from 10 to 50 pounds. Its orange-colored fecula is filled, of course, with the common calcium oxalate needle-like crystals. Cut up in chunks and boiled, however, this can be eaten. The young petiole and leaf-bud may be boiled and eaten as a coarse spinach.

There are several species of Plectranthus and Coleus, belonging to the Labiatæ, native to Africa and the East Indies, and several of these produce small edible tubers. Some, like the kemili of Sumatra and the interesting species of the western Sudan countries, were expected to do well in tropical stations; thus far, however, climate

elevation, or soil (nematodes in Porto Rico) have not been favorable.

The sincamas or yam bean, *Pachyrhizus tuberosus,* is one of the very few Leguminosæ which produces edible starchy roots. This widely grown though but little known bean-like plant has been talked about for half a century, and it certainly has great potential value as an all-around garden or field crop; but it appears less common today than it was a score of years ago. The original habitat is absolutely unknown. It appears to reach its maximum development and popularity in Mexico, where there are at least two distinct varieties. Sincamas is the old name. Macmillan states that it is naturalized in the Philippines and that it has blue- and white-flowered varieties.

The vine of yam bean may reach to the top of a fairly tall tree and may live for two seasons. It requires support. The hills need plenty of space. The roots are more or less turnip-shaped and weigh when ready for eating from 15 to 30 ounces; the younger they are the better for eating raw; they are often cooked. They are sweeter than the ordinary turnip and of about the same texture. In the markets of the Mexican mesa, they are one of the commonest and cheapest vegetables. The young half-ripe pods may be used like string-beans. The ripe pods are from 6 to 8 inches long.

The sincamas is a perplexing crop. In some cases a most luxuriant plant may never produce either flowers or roots; or it may bear hundreds of stiff brown pods but not a pound of roots. This unreliability of yield probably explains in part its unpopularity among agronomists. The removal of the flower-clusters sometimes induces root formation. The tuber-like roots never sprout.

The starch from the roots is perhaps the most brilliant of any known sort. The leathery rind peels off readily. The fiber-content is hardly greater than that of cassava.

In some of the Antilles the coral limestone hills are covered with innumerable specimens of marunguey or, as

known in Florida, coontie. These are cycads of the genus Zamia. Porto Rico has three species and there are probably several in the other islands. The swollen stem of these plants is full of a brilliant white starch; it also contains a principle which sets free hydrocyanic acid in great abundance so that care must be taken to keep the dogs and chickens from drinking the milk-like washing-water.

The two great difficulties in preparing starch from these zamias are their habit of burying the base of the stem in the holes and crevices of the honeycombed coral rock so that a crowbar is necessary to pry them out; and also the trouble in shaving or chopping off the thick scaly bark.

In Mexico one of the giant cycads, *Dioon edule,* bears large edible seeds which, as well as the 6- to 10-foot trunk, produce sago starch just like the marunguey which hides underground. Also in Australia, Indo-China, Celebes, and South Africa there are numerous other Cycas, Zamia, Macrozamia, and other related generá; their seeds or stems yield starch. However, these are not root-crops, strictly speaking, although the stem or trunk may be a subterranean rhizome.

The chayote or christophine, *Sechium edule,* produces irregular-shaped starchy tuber-like roots, if left long enough, and these could be fed to pigs.

In many parts of Polynesia and in some localities in south China and Malaya the ti shrub, *Cordyline* (*Dracœna*) *terminalis,* is semi-cultivated for its long tuberous roots which are full of starch and a saccharine substance. When roasted these roots are said to have the flavor of caramelized sugar. The roots may be used for stock-feed or, fermented, for liquor. The young leaves are cattle forage and the mature ones yield a coarse fiber. Ti is of very easy propagation by cuttings and is noted for its tendency to sport. Horticulturists could readily breed up many superior varieties with high sucrose and starch-content. It grows rapidly in almost any soil.

The famous old lotus, *Nelumbium Nelumbo,* of south Asia

and tropical Africa is cultivated as a root-crop in China and Hawaii. Wilcox [1] states that the rootstock contains 70 per cent starch. The large seeds are also farinaceous and quite edible, an important food material in the swampy Cotabato Valley of Mindanao. The lotus has already been broken up into very many forms and types by the Japanese and Chinese gardeners, and since these root-crops can be planted in swamps and stream-beds where ordinary plants cannot exist, it is a wonder that there are so few lotus-eaters in the world today.

Another group of plants, which should be cultivated wherever there is a waste water area in the tropics, are the lattice-leafs, of the genus Aponogeton or Ouvirandra. These very interesting and unique plants have net-like leaves, veins without much parenchyma, and large starchy edible rhizomes, like yams. There are some twenty to thirty species indigenous to Madagascar (four species, including the famous *A. fenestralis,* grown everywhere as an ornamental aquatic), South Africa, and Malaya.

Another group are the trapas, three or four species of floating aquatics. The ling (*Trapa bicornis*) of south China has large black seeds shaped like a bull's head. They taste a little like the chestnut, raw or cooked, hence the trade name water chestnut. The singhara-nut of India and Ceylon is *T. bispinosa.* It is grown in the tanks, the floating plants forming a blanket which keeps these reservoirs cool.

The arracacha, *Arracacia xanthorrhiza,* is a worthy but little known root-crop domesticated by the pre-Incas and still cultivated thoughout northern South America and some parts of the West Indies. It is related to celery and combines the good qualities of that vegetable with those of the carrot and the parsnip. It has been cultivated so long that it seldom or, in most places, never flowers. Unlike most root-crops the offsets which form around the base of the mother root may be removed without injuring the remainder of the stool; thus a few arracacha hills, or

[1] Wilcox, E. V., "Tropical Agriculture," 1924.

stools, in the kitchen garden furnish a constant supply of this very rich, nutritious, and flavory root.

Another of the old Inca root-crops was the anyu, *Tropæolum tuberosum,* one of the rarest and most difficult to cultivate. The small leaves as well as the irregular-shaped tubers are eaten.

Other strange crops of that region were the ocas, *Oxalis crenata* and *O. tuberosa.* These delicate but very interesting plants have been grown to some extent in Europe but they seem to languish for the cool mountain valleys of the Andes.

The Incas' ullucos, *Ullucus tuberosus,* is called by the present-day inhabitants "papa lisa." It belongs to the small family Basellaceæ and is well worth attention.

Still another root-crop in the Ollantaytambo region was the llacón or aricuma, Polymnia, a relative of the sunroot, *Helianthus tuberosus,* of North America. Unfortunately this crop and its smaller relative, the pante, have been neglected to date, although they have excellent possibilities especially in view of the renewed interest in sunroot as one of the great sugar crops of the future.

CHAPTER XX

TOBACCO

TOBACCO was originally a tropical crop. It was chewed, smoked, and taken as snuff by the aborigines before the Spaniards reached the New World. Incidentally it should be remembered that a "tabako" was a nose-pipe for inhaling the fumes of roasting seeds of cohoba (Piptadenia species), especially in Haiti and Quisqueya (now Santo Domingo). *Nicotiana Tabacum* was the tobacco first noted in the Antilles, and this has been bred up and hybridized and has sported so greatly that today there are probably 100 varieties under cultivation, in practically every country of both hemispheres. *N. rustica* was found both wild and cultivated in Mexico; it is now grown largely for the high nicotine-content of its leaves, for insecticides.

Generally speaking, tobacco in the tropics is a rather expensive crop to manage, reckoning the large amount of hand labor, fertilizer, and post-harvest operations. A yield of 500 to 1,500 pounds of cured leaf may be secured to the acre if the following conditions are provided: a well-drained soil, not too sandy, alluvium or hillside; good tilth and clean cultivation; a moderate even rainfall; no strong winds; and protection from pests and diseases.

The value of the leaf depends largely on the variety, the size and texture, the curing, and finally the fermentation. The price may vary from 15 cents for ordinary cigar "filler" or pipe grades to $1.00 or more a pound for "wrapper."

Selected seed is secured pure in the best plantations by bagging—inclosing the terminal cluster of flowers in a waxed-paper or muslin bag (to prevent cross-pollination).

When thoroughly ripe the seed heads are harvested, dried, and threshed by beating, the minute brown seeds being first picked over by hand and then winnowed. Of late years a blower apparatus devised by the United States Department of Agriculture has come into use: a foot bellows forces a current of air upward through a vertical glass tube about 4 feet long by about 1 inch in diameter—the lighter and practically worthless seeds (say, 15 per cent) being thus blown out of the top of the tube.

The seeds, mixed with fertilizer or ashes, are sown (2 to 3 pounds to the acre) in sterilized, or at least clean, beds of rich soil, preferably under cheesecloth; liberal amounts of fertilizer are often used to force the young plants. From these beds the seedlings are pulled when 4 to 6 inches high and transplanted into the field.

The plants should stand about 3 by 1 or 1½ feet for ordinary open field culture: less space for small varieties or on hillsides, more for large sorts or for shade culture. The rows should be far enough apart to allow a small cultivator to pass (Plate XXIII).

The terminal bud should be pinched off to keep the strength back in the leaves (12 to 18 or more), though this topping must be skillfully done at the proper time or it may result in too many side shoots or in leggy stems. After three to four or perhaps 4½ months, the first leaves may be picked. Side shoots should be removed if large fine leaves, and not quantity of leaf, are desired.

In some districts no separate leaves are plucked, the entire plant being pulled up or cut by hand at the time when most of the leaves on the stem are ripe. Individual plants vary, of course, in ripening and only trained workers can tell just when the leaves acquire the right snap (by doubling the midrib). Whether entire plants or leaves, graded according to size, form, and the like, are harvested, the green material goes into a curing shed or barn, built to protect the crop from sun, dry air currents, and excessive humidity.

Hung on sticks suspended horizontally in great racks, the leaves in pairs, or the whole stems, undergo a slow curing process, or dry fermentation, gradually turning yellowish-brown and becoming tough. Depending on temperature, kind of leaf, and other factors, from three to six weeks suffice to develop the nicotine-content and to bring about a certain texture which most tobaccos require. During rainy weather charcoal fires inside the barn prevent damage to the over-moist leaf.

The leaves are taken down and made up into small bundles. These may be kept intact for weeks or months, but usually the final process may be started at once. These bundles of cured, tough and strong-flavored leaves are piled on the floor into oblong heaps, say 5 feet wide by 10 or 12 long by 6 or 7 high, containing half a ton or more. These heaps may require sprinkling to give the proper degree of moisture for starting the true fermentation—which develops the aroma and bouquet of the leaf. After several taking-down and rebuilding operations, to prevent over- or irregular heating, the entire heap should be evenly fermented. A temperature of 120° F. in a heap of wrapper leaf is near the danger limit, but filler leaf may go to 140° F. safely if the texture is heavy. Four to six weeks are usually allowed for the fermentation process. Through some complex enzymotic changes in the leaf tissues and their cell contents, depending partly on organized ferments but largely on unorganized, *i.e.*, germ-less fermentation bodies or virus-like enzymes, the raw biting tang is sweated out and in its place comes the well-known but hardly describable bouquet and taste of the finished leaf. These bacteria and enzyme bodies have been investigated somewhat, but much still remains beyond the realm of classified knowledge of tobacco.

The tobacco grower has four pests and two or three serious diseases to combat. Obviously, the application of poison sprays is impossible, except on young plants.

In most countries the large sphinx-moth caterpillar, or

horn-worm (Protoparce sp.), requires hand-picking. The flea-beetle is also very common, and causes millions of dollars loss yearly, by eating small holes in the leaf. A leaf-roller and a leaf-miner are, in some localities, serious pests. A mixture of air-slaked lime and arsenate of lead (50 to 50) dusted onto the leaves is recommended for these pests. Paris green is liable to burn the tender leaves. Flour should not be used as a carrier: it may stick to the leaves permanently.

Mosaic is a widely prevalent and serious disease of uncertain nature and origin. Eradication of infected plants is necessary; sprays appear useless. It is so readily transmissible that neither tobacco dust nor stems should be used as fertilizer either in the seed-bed or in the field.

Several fungous root diseases are common, especially in poorly drained fields. Surprisingly few diseases attack the delicate lush leaf. The stem and inflorescence are also practically free from disease.

United States produces from one-third to a half of the world's tobacco, India comes next with probably 500,000,000 pounds or more—though a vast quantity is imported besides. There has always been a mystery about the enormous consumption of tobacco in India: one seldom sees the natives smoking—the aristocratic and expensive hookahs could not burn up 1 per cent of it—but it appears that vast amounts are used in various narcotic masticatory mixtures, drugs, and confections, *i.e.*, most of it eaten rather than smoked. Next in importance are the Balkan States, with Greece in the lead. Then comes Dutch East Indies, with perhaps 25,000,000 pounds. The Japanese Empire vies with Brazil in mass of production—each around 150,000,000 pounds a year. Russia used to grow an enormous crop of strong leaf, but the present production is probably only a fraction of the pre-War outturn. The China crop, also, is unknown.

Belgium leads the world in yield to the acre—over a ton, as against 750 to 800 pounds for the United States.

The total crop of both hemispheres is now probably well over 3,500,000,000 pounds, say 2 pounds per capita.

Asia Minor produces some of the best tobaccos, at least as far as distinctive flavor and blending qualities go.

Cuba, Porto Rico, Santo Domingo, and Brazil produce most of the tropical American tobacco.

Tobacco will grow fairly well in Central Africa, Colombia, or Sumatra; but unless careful experienced supervision is in evidence from seed-bed to fermentation heap the quantity outturn as well as the quality may easily be very discouraging. A Maya Indian can raise a few pounds of tough leaves on a plat large enough to furnish a Cuban expert with a bale of costly "capa."

Tobacco should be rotated with legume and cereal crops. In many countries the fields lie fallow one or two years between the tobacco crops.

The outlook for tobacco growing is fairly good. Though there are several competing products—opium and hashish the most widely used—no plants contain nicotine except the Nicotiana species. For some obscure reason nearly all races and classes of mankind enjoy the effects of nicotine and, whether smoked, chewed, inhaled (as snuff), or (as in India) eaten, the tobacco habit is readily formed.

It seems strange that other mild drug materials are not more often mixed with tobacco. Presumably the future will see many ingredients blended with the leaf of nicotiana and this may increase the world consumption considerably —without, of course, necessarily, causing any ill effects.

CHAPTER XXI

BEVERAGES AND MASTICATORIES

THERE remain several beverage products that may be assembled in one chapter; and with them may be discussed materials of similar human use, such as are chewed for the flavor or the stimulating qualities. While these products may be of great importance in certain regions or with races of people, they are not of general or widespread commercial interest.

BEVERAGES

After tea, coffee, and cacao, the next most important beverage crop is maté. This shrub or small tree greatly resembles tea, especially as to the color and shape of the leaves. The flavor of the infusion of the dried leaves of this Paraguay tea, *Ilex paraguariensis* of the Aquifoliaceæ, is excellent, though very unlike that of the true tea.

The leaves contain about the same amount of caffein as tea leaves; there is no question as to their stimulating quality. Twenty-five million people in Brazil, Uruguay, Paraguay, and Argentina consume some 75,000 tons of maté annually. Small amounts go to Europe and North America but the habit, strangely enough, has never developed much outside of the said countries.

Instead of picking buds and single leaves maté branches are chopped off, dried in the sun, then over wood fires, and coarsely ground. The cheaper grades contain some branch tips.

Formerly only the wild trees were cropped, but in the last two decades plantations have been started. South Brazil produces most of the maté leaf.

Khat, *Catha edulis*, is the principal beverage of Arabia. Long before coffee was introduced from Africa, the khat shrubs were cultivated in the terraced gardens of western Arabia, perhaps even before tea was known in China. It belongs to the Celastraceæ. The khat shrub resembles tea even more than does maté. The dark green leaves are pleasant to chew, either fresh or dried, much better than tea. Outside of Arabia and the countries along the opposite side of the Red Sea, this first-class beverage plant has never become popular.

Guaraná is the most stimulating of all similar beverages. A large coarse Sapindaceous liana, *Paullinia Capana*, of the Amazon Valley has good-sized fruits containing numerous small seeds. These latter are ground into a thick paste which is usually made up into chocolate-brown cylinders about 4 inches long by 1½ in diameter. A few of these dry sticks of guaraná should be in every explorer's pack; half a spoonful of this shaved off into a cup of boiling water makes a very refreshing drink though slightly bitter, and equal to two or three cups of coffee. These rolls keep perfectly for years even in a humid locality. The seeds contain 4 to 5 per cent of guaranine, an alkaloid very similar to caffein. Unfortunately guaraná will probably remain a wild crop; it has been used for ages, however, by the natives from Pará to the Bolivian Andes.

Kava-kava or awa, *Piper methysticum*, is a small shrub native to the eastern Pacific archipelagoes. Though very closely related to black pepper, this species seems to lack the pungency of the spice pipers, the roots being the crop material. Long before the arrival of Captain Cook the Polynesians had developed a cult or custom of kava drinking to a very remarkable degree. The coarse irregular-shaped roots are 50 per cent starch; they also contain oleoresins which have a slow but prolonged effect on the nerve centers. Formerly these roots were chewed by youths and the semi-liquid material, after being carefully diluted and fermented in ceremonial bowls or troughs, was drunk in

large amounts, unless the drinker was a novice, in which case more than two or three cups might produce a general paralysis of muscles as well as mind or death. Kava-kava is sometimes cultivated. It is propagated from cuttings.

MASTICATORIES

Kola is twice as stimulating as coffee, but lacks the pronounced aroma. It is both a masticatory and a beverage. Fifty million people use it. There is scarcely an individual in the triangle—Gambia-Abyssinia-Congo—who does not use it more or less if and when it can be obtained. It is comparatively an expensive commodity; starting on the West Coast at the price of, say 10 seeds for 1 cent, its value goes up rapidly, about 100 times, till in the eastern Sudan a white kola seed may cost 10 cents worth of barter goods.

Cola acuminata is the name usually applied to this small tree, 15 to 25 feet, of the Sterculiaceæ which produces most of the kola of commerce. There are some 100 other species (according to Chevalier, who has monographed them), all African; many yield edible seeds. Botanically closely related to cacao, the trees resemble each other in size and habit. The fruits are really not so dissimilar as they look; the seeds of both are inclosed in a watery sweetish pulp, but the kola pods are borne in clusters of three to five at the ends of small branches (instead of from raised wart-like cushions on the trunk and large limbs) and each fruit is ridged and irregularly knobbed, two-valved as to the thick woody pericarp, and more or less bent and twisted. The seeds vary from two to five and are flattened irregularly, somewhat lozenge- or lens-shaped, about 1½ inches in diameter by ½ to 1 inch in thickness at the middle. Most kola seeds are pinkish or purplish, drying to a dull brownish color; some are nearly white when fresh, and these bring a higher price in the native markets, largely because of custom. The colored seeds must suffice among the lower class.

PLATE XXIII.—Above: Igorot women planting lowland rice seedlings, Philippine Islands. *Below:* tobacco plantations, Porto Rico; shade used mostly for the seed-beds.

Europe has recognized, if not appreciated, the value of kola for half a century or more; America has yet to learn to use it. From the hinterland of Liberia mostly, there goes out down the old railway from Pendembu to Freetown some 2,800 tons or more and out from the Gold Coast nearly 8,000 tons besides the enormous bulk of the hinterland trade. The little colony of Gambia imported over 1,000 tons in 1920. The European market absorbs yearly only some 10,000 tons now. There it goes into chocolate and into various tonic wines and soft drinks. The caffein-content varies from 1 to 3 per cent or more; there are other alkaloids the action of which is not well understood yet. For every pound that is exported to Europe a hundredweight probably is absorbed into the vast realms of the Sudan. From a certain hill in northeastern Liberia an observer can see during the main crop season, not hundreds but thousands of porters, each with his or her "canja"—some for the head, some for the back—holding 40 to 60 or 70 pounds of the fresh seeds packed in leaves. The lines of these freight carriers converge and diverge in a network of foot-paths covering thousands of square miles. It is a big business, though the outside world heeds it not. It has a great future. Instead of the few hundred scattering and only partially cultivated trees around barbarian villages, there will eventuate regular groves yielding heavy crops twice a year. Select strains will appear. Kola is appreciated by its 50,000,000 or so users not merely for its highly stimulating caffein qualities but also for the peculiarly pleasant effect of its mysterious alkaloid. It has been grown with considerable success in Jamaica and one or two places in northern South America. Almost every collection of economic plants has a few specimens throughout the West Indies. If public demand should call for it, it could be grown extensively and probably with good profit almost anywhere in tropical America.

Coca, *Erythroxylon Coca*, is a delicate-appearing shrub, 4 to 6 feet high, native to the Andean region, where it has

been used for ages by the Amerinds. It is related to the flax plant. The leaves contain, when dry, about 1 per cent of cocaine, one of the most powerful alkaloids in the vegetable kingdom. A small handful of the dried leaves, chewed slowly with a little lime, will keep even a Quichua habitué in a semi-conscious state for a day or two. During the time the drug is in action the individual requires neither food nor drink yet is capable of great exertion even in the very high altitudes from Bolivia to Colombia. Coca is very amenable to cultivation at moderate elevations. For obvious reasons the British government prohibited coca planting in its colonies since 1914. A tea is sometimes made from the leaves. The leaves should be dried in the shade. This shrub is the only known source of the almost indispensable drug cocaine.

Betel-nut, or pan, *Areca Catechu,* is a graceful small-stemmed palm, probably native to some part of Malaya. It is chewed by more individuals than any other masticatory. From Indo-China through the Philippines and all of the Malayan countries to western India, the amount of this excellent stimulant-narcotic consumed is almost incredible, probably much over 50,000 tons per annum. Ceylon exports a surplus, comparatively small, of some 7,000 tons to India; Macmillan estimates that no less than 70,000 acres are in pan in Ceylon alone. There are several varieties. Since 4,000 to 5,000 palms may be crowded into an acre, and since most of these will yield 200 to 250 fruits each a year, a million to the acre, it is evident that this is a tremendous crop. Incidentally this palm catechu is not the catechu dyestuff; *Acacia Catechu,* a tree of Burma and India, has wood used in making catechu cutch, something like the cutch from mangrove bark. Betel has several uses in medicine; but 99 per cent of it is chewed with lime, wrapped in the betel pepper leaf.

CHAPTER XXII

SPICES

THE appetite for and habit of spice eating has been one of the great factors in human progress; in fact, probably no other crop group has helped so much to promote international relations. One of the first items of international trade was Chinese cinnamon, carried in caravans with silk and myrrh overland to the Mediterranean.

The opening of the Middle East in the sixteenth century was due largely to the spice hunger of Europe; and Columbus had in the back of his mind the possible return cargo of pepper, cloves, and cinnamon from "the Indias." At the prices his ships could well have carried back $500,000 worth of such merchandise.

Not only to season insipid or salty foods were spices so eagerly sought in the Middle Ages. They were used to preserve foodstuffs and also as medicines and brews. They were even at times used in lieu of money. The wealthy flaunted spices to prove their position; the middle classes had to follow suit; and the poor people reveled in the luxury far beyond their means.

Speculators, middlemen, and importers made fortunes between 1300 and 1700 A.D. Cinnamon and cloves were then worth about twice their weight in gold in Europe.

As a proof of the commercial importance of spices, the United States pays about $20,000,000 a year for some 50,000 tons of these raw materials, which are worth twice as much in the retail trade.

VANILLA

As one of the most popular spices vanilla deserves much more attention than it has thus far received. The wide-

spread lack of knowledge concerning one of the world's commonest flavoring substances is remarkable. Though of course the artificial substitute, vanillin, has been taking the place of the natural article since the early nineties, the average individual tastes vanilla in confectionery, pastry, ice cream, about every day. Cinnamon, cloves, nutmegs and cardamons are fairly familiar in the raw unground state, yet probably not 1 per cent of the people have a clear mental picture of what a vanilla "bean" looks like, or what sort of plant produces it.

The Aztecs had long been using the fragrant and flavory black pods to grind up with cacao in the making of their national drink, chocolatl. The Spaniards must have been impressed with the exquisite flavor of the mysterious product, but they probably had no idea how the crop was managed. The first botanical mention of vanilla seems to have been made by Clusius as early as 1605, but nothing definite as to the plant was learned for another two centuries.

The public demand for this unique flavoring material finally became so strong in the second half of the last century that the limited area of the east coast of Mexico, the Papantla district of steaming jungles between Vera Cruz and Tampico, could not supply it. Then cuttings were taken to Reunion, Java, Madagascar, the Seychelles, and Tahiti; it reached Reunion in 1818 but there was no great incentive for cultivating it till 1850. Guadeloupe has recently been in the lead. Porto Rico, with only one sizable plantation, has set an excellent record, $2,300 to the acre. The Grand Comore archipelago, northwest of Madagascar, was once the focus. Mexico is now producing about 185 tons per annum.

Although two or three very serious fungous diseases have for a decade been threatening the industry, it seems to be steadily increasing. The total output is now about 650 tons, worth anywhere from $3,000,000 to nearly $10,000,000. The price fluctuates greatly. In 1924 the London market

once offered 70 shillings a pound. About $4 to $5 is the optimum export value.

The Java article is considered the strongest as to vanillin-content (about 2.75 to "7.9" per cent), but the Mexican bean is still the most in demand although it has little more than half as much of that chemical compound. The present output of Java vanilla runs around 15 to 25 tons, but by 1930 it is estimated the figure may go up to 75 tons.

Out of the 7,000 or more species of Orchidaceæ only a very limited number combine the two distinct habits of the family: the species of Vanilla are vines and derive part of their nourishment from the soil and part from the surface detritus on the bark of supporting trees. This scheme seems to be extremely successful, so much so that one species may be regarded as the longest if not heaviest orchid, sometimes ascending to the tops of tall forest trees and then growing downward to the ground, a length of some 100 feet or more.

Vanilla planifolia supplies fully 90 per cent of the crop; it originated in the "tierra caliente" of eastern Mexico, where it still grows wild and where it is fertilized by small bees. *V. Pompona,* the vanillon or vanilloes, is another Mexican species with a larger stem and shorter thicker pods. The vanillas of Colombia appear to be confused botanically.

The site of a vanilla plantation should be protected from winds, have plenty of humidity with only moderate dry periods, perhaps a few thousand feet elevation, perfect drainage, preferably a pronounced slope. Soil is hardly necessary, though the roots of course do take up a very little matter, enough to give a trace of ash in the plant tissues.

Supports are necessary, either trees, posts, wires or fences. A dozen or more species of trees and large shrubs are used. The best seem to be the rapid-growing spineless erythrinas. These "bocares" or "dadaps," as they are called in Malaya, grow readily from stake cuttings; a 6-foot stake, 3 inches thick, should be ready for the vine cuttings to start climbing in less than a year. The supports should be set, accord-

ing to the slope of the land, danger from grass and weeds, from about 6 by 6 feet to 10 by 10; 8 by 8 gives 680 plants to the acre. Where root disease threatens it is better to plant closely and rush the vines the first three or four years. Erythrinas grow so very rapidly that an expert pruner is required to keep them from over-shading the vines. The prunings, chopped up, and piled about the base of the trunk, furnish a cool nest for the short and weak roots of the vanilla. Branches should be encouraged at the height most convenient for the pollinators, say 4 to 7 feet.

The vine cuttings should have not less than three and would better have eight or ten leaf-nodes unless the mother vines are very vigorous. They should be set with the base of the cutting just covered with surface soil or leaves. Usually it is safer to tie loosely the upper end to the support trunk. In six months most of the cuttings will have started new shoots at the upper nodes. The lower three nodes send down roots. Vigorous cuttings may strike root in ten weeks. When the root-rot disease is virulent the lower end of the cuttings should be left exposed (dry) to avoid entrance of the fungus and two nodes should lie, partly covered, on the mulch bed at the foot of the support. The cuttings if carefully packed may be kept for weeks before planting.

Beyond pulling up weeds near the supports and keeping down all grass in the interspaces, no machete or hoe should be allowed within 6 feet of the support base, so delicate and liable to wound diseases are the vanilla roots.

Careful removal of surplus branches, or runners, of the vines is occasionally necessary. The main branches should be trained so that when the flowers appear they will nearly all be within reach of the workers. Vigorous runners grow nearly an inch a day. Pendent runners may be pinched back when the tips reach nearly to the ground.

Strong vines may flower about a year after planting; usually some eighteen months are required to bring the first blossoms. The flowering period lasts, fortunately, some

eight weeks. The inflorescence bud takes about the same period to produce the open greenish-yellow flowers. The ovary, or immature pod, is about 2 inches long; the flower-tube about 2½. The flowers, 15 to 30 or more, open several at a time in clusters. A plant may produce 2 to 200 bunches at a time. From three or four to a dozen flowers in each cluster are fertilized, the others drop.

The stigma is so covered that unless it is raised toward the anther and the pollen pressed out simultaneously, the thousands of ovules will not develop. A short stick or bamboo splinter in the hand of an experienced pollinator readily effects the contact. A trained worker can pollinate 200 flowers an hour. This operation must be done before 2:00 P.M., while the pollen is ready to shed freely; each flower is viable for only six hours or so. Since long pods are in greater demand, both for their appearance and for their slightly better extracting quality, it is usual to pollinate only a few flowers in each cluster, and preferably only those which will give a vertical-hanging straight pod. An 8-inch pod weighs at the end of the curing more than twice as much as a 6-inch one and three times as much as a 5-inch. While the ovary becomes a full-sized fruit in about two months, it takes seven to ten months to ripen the pod fully. Loss occurs frequently from the tips of pods splitting if allowed actually to ripen on the vine.

Picking requires considerable care, not to injure the pod itself nor to break the inflorescence stem where it might affect other fruits.

There are many ways of handling the pods after picking. Up to about 1900 the famous Papantla vanilla of Mexico was handled almost entirely by Indian peons who used the old zerape, or blanket, method of curing: exposure to sun and rolling up in the blanket at night or in bad weather. The variations of the sweating process are interesting, but the main objects are as follows:

The pod rind is treated so that, with no risk of its splitting at the tip or of cracking the side walls, it becomes

pliable but tough, collapsed but solid. The pulpy seed-mass inside must gradually be softened till a slight pressure outside will move it readily. When the pericarp wrinkles and turns, evenly, a dark chocolate-brown or nearly black it may be ready for the slow drying. Curing is generally applied to the sweating period of several days or a week or more, and to the slow drying which may take six to nine weeks, depending on size of pod and weather. Artificial heat can be used by experts to hasten the curing. Molds are very troublesome on the drying shelves.

The finished pod should be more or less supple and not dry enough to break; it should have a greasy feeling and should show minute sparkling crystals of the vanillin on the surface. The pods must be inspected very carefully every day to allow no mold spores to scatter. Finally the delightfully aromatic pods are tied in parcels and packed in paper-lined air-tight tins for shipping. The lower grades are sometimes shipped in bulk.

Artificial vanillin is manufactured on a large scale from several materials. Crude clove oil is perhaps the commonest of these. Massoi bark, the product of an unknown forest tree of Papua, contains much of this eugenol and may become a staple commodity. Synthetic vanillin seems to be harmless in the human system, and its taste is practically indistinguishable from the natural article. It is largely used in the ice-cream and confectionery industries.

There has been much discussion concerning the itch which frequently troubles the hands of vanilla workers. The greatest factor is the raphides contained in the sap of the plant; thus in cutting the pods, a drop of the juice may come in contact with the fingers which may then accidentally touch the more sensitive skin of the neck or face. The needles of calcium oxalate then penetrate to the nerves, causing a severe burning sensation which may last for several hours. These acicular crystals are fortunately gradually soluble in the tissues. The crystals of vanillin, which are more or less in evidence on the outside of the

cured beans or pods, may also irritate the skin of the workers handling them in making up into the bundles. In some localities it is reported that a very minute mite (Acarus) living in the tips of the fruits may leave their nidus and enter the skin of those handling the fresh pods. It is debatable whether the natural oil of the mesocarp, which seeps out through the pericarp of the cured bean, can irritate the skin. The main trouble can be largely obviated by the workers who prune the runners or pick the pods wearing glove fingers and avoiding touching the face or neck. In this connection it is interesting to note that some individuals are immune to raphides. The pathologists have had to coin a word, vanillism, for the series of symptoms which range from the local itching to vertigo and prostration. Part of these effects, however, may be due to some oily substance applied to the pods in curing.

The fungus root-rot may seriously hamper the cultivation of vanilla wherever it exists; control measures, however, may be found. The leaf and pod fungi can probably be kept in check, but vanilla does not take so kindly to sprays as do citrus fruits.

A new method to prevent the splitting of pods while drying has been adopted by some vanilla growers. At the beginning of the curing process the "green beans" are scratched on both sides from end to end, by means of a pair of pins or needles set in the tip of a small stick. The pericarp must not be scratched deep enough to reach the pulp. The short pods do not need this treatment. For some unexplained reason, needled beans color much more rapidly in the curing.

CINNAMON

The oldest vegetable material used for flavoring food is cassia or Chinese cinnamon, *Cinnamomum Cassia,* native to subtropical China and still very largely confined to its original habitat. Records indicate that it was used in China before 2700 B.C.

This false cinnamon is practically as good for most purposes as the genuine. United States imports about 4,000 tons as against 600 tons of the true article.

Some 60,000 acres are said to be in cassia. The Chinese growers have never adopted the Ceylon system for obtaining quickly and easily the long straight "quills" of bark. They let the tree grow for several years (30 to 50 feet), then fell it and remove the bark from the branches. When scraped and dried in the sun the irregular pieces of bark are baled.

The dried unripe fruits are known in trade as "cassia buds," and no better flavored spice exists. The leaves and thick bark are distilled for cassia oil which has a variety of uses, in confectionery, soap scenting, and the like.

Cinnamon, *Cinnamomum zeylanicum,* was discovered in the jungles of Ceylon and south India centuries after Chinese cassia was well known. It promptly superseded the older spice, however, and great efforts were made, first by the Portuguese then by the Dutch, to control its export. Its cultivation began in 1770 while the Dutch were holding Ceylon. In recent years cinnamon culture has been developed to a high degree. Now the plant is grown not as the 50-foot tree but as a sapling bush, and, in order to have neat straight stems for the higher-priced long quills, these saplings are set (either as cuttings or seedlings) a foot or so apart in a circular clump about a yard in diameter, the clusters of bushes being some two yards apart. At about two years of age and when "flushing" the largest stems in the stool are cut, the remainder later. Two crops a year may be obtained in good land.

The bark is removed in half cylinders. After a partial fermentation the outer layer of cortex is scraped off. The clean quills are then sun-dried; the smaller quills are put inside the larger, thus making the pipes, in which form the best bark is marketed. A large part of the bark, however, is in broken pieces, chips and featherings, and these are usually distilled for cinnamon oil. Leaf oil and oil from

the bark of non-peelable branches and stems are also in trade.

Several varieties are recognized locally in Ceylon. In Burma, Papua, and Malaya there are other species, some of which are beginning to enter commerce. Massoi bark (Massoia sp.), of New Guinea, will probably be cultivated as a source of crude eugenol for vanillin manufacture.

The family, Lauraceæ, is famous for its aromas and high-flavored substances.

PEPPER

Black pepper, *Piper nigrum,* is an uninteresting-looking weak-growing vine of the large family Piperaceæ, native to the Indo-Malayan region. It is a cultigen. Pepper began to be exported to Europe long before Vasco da Gama arrived in 1497; Bactrian camels first, then via Persia on dromedaries down to the rich cities around the eastern Mediterranean.

Pepper now is produced principally in Java, Sumatra, British Malaya, Malabar Coast of India, and in Ceylon. United States imports 10,000 to 18,000 tons a year, worth nearly $5,000,000.

The pepper vine is propagated from tip cuttings. It requires support and most varieties enjoy shade and humidity; live trees are generally used. There are a dozen or more distinct sorts of this species; several similar species produce grains for the trade. The Trang of Siam is the best.

When the runners are 10 to 15 feet long, in the third year, the small green catkins appear. The round berries on these three- to five-inch catkins turn a peculiar reddish color when ripe. These berries, spread out on barbecues or trays in the sun, rapidly become black and shriveled and very odorous.

White pepper is made by soaking the black berries in water several days till the outer hull may be rubbed off by hand, trodden off, or decorticated by machinery. Some

of the sharp piquancy is lost, of course, in this soaking, but white always brings a higher price than black.

The vines with good care may produce two crops a year for twenty years or more. About a ton of marketable grains is the usual yield, reckoning 800 to 900 vine clumps to the acre and 10 to 14 pounds to a vine.

Long pepper, *P. longum,* is similar to the black vine, but grows much more rapidly and bears earlier. The grains are not so strongly pungent. It is cultivated in India, where there is one variety known as the pipat or pippul (Sanskrit Pipal, from which comes the English word). Java also has a variety, *P. officinarum.*

Betel pepper, *P. Betle,* is one of the commonest cultivated crops in the Middle and Far East. For many centuries the leaves of this old masticatory have been used in making up the "pan" quid, slices of betel-nut, pinch of lime, perhaps a cardamon or piece of tobacco leaf, all wrapped in the betel leaf—probably the best of the narcotic-stimulant masticatories in the world, notwithstanding its abominable effect on the saliva.

Piperonal, or pepper oil, is the source of synthetic heliotrope essence, on a par with clove oil for vanillin.

Melegueta pepper, Guinea grains, or grains of paradise, *Amomum Melegueta* of the Zingiberaceæ, is a rather common-looking plant with a very beautiful lavender or violet flower, native to the Guinea Coast, to a portion of which it gave the name Grains Coast (Liberia). It is closely related to ginger but is a much larger plant, an old stool usually standing as high as a man's head. It prefers the borders of sluggish streams or swamps but also grows in light forest. There are two botanical varieties; neither is cultivated to any great extent. Six or seven centuries ago it was in great favor in Europe and rivaled the true peppers in commercial importance. The pungency of the ripe fresh brownish seed is nearly equal to capsicum, but the spicy aroma is quite unlike that of any other condiment. For its orchid-like flowers, fragrant leaves, aromatic rootstock, attractive orange pear-shaped fruit filled with the very aromatic

golden-brown seeds, this plant stands unique among economics.

GINGER

Ginger, *Zingiber officinale,* is native to some part of tropical Asia. It is a cultigen and now common in every tropical country. It is an erect herb, 2 to 3 feet high, growing from thickened rhizomes which branch finger-like and send up new shoots from the tips near the soil surface.

These rootstocks are greenish-yellow inside with a pale yellow pellicle outside; some hands, or rhizome clusters, turn bluish in drying. The hands are scalded and scraped or else dried in the sun or an oven. The peeled is preferred by most buyers, probably because it is kept from moldiness by the dust coating of lime. Ginger-root varies greatly in oleo-resin-content and in aroma. The Jamaican article is most popular, that from India less so, the Sierra Leone root least so. Southern China produces some choice root which is largely candied.

It is debatable whether ginger does better in sandy or clayey soil. It is harvested easier in loose soil, but if the roots suffer from any lack of moisture the yield comes down. A fair acre in Porto Rico will turn out 2 to 3 tons of fresh clean root; this dried thoroughly will weigh only about one-third as much.

Seeds are probably never ripened. Pieces of the rhizome may be broadcasted, bedded, or set in rows. Ginger grows equally well in shade or sun.

Ginger went with pepper and cassia by the caravan route to the Levant before Rome was founded. It will long remain one of the world's most popular and wholesome spices; it deserves much larger consumption. United States imports some 2,500 tons a year.

NUTMEG AND MACE

The nutmeg, *Myristica fragrans,* is an ideal spice and deservedly very popular. It is indigenous in the Molucca Islands, and was closely guarded there, as a sort of gold

meg in the Moluccas. Introduced into Mauritius in 1770 by Governor Poivre, and thence into Pemba and Zanzibar, it succeeded so well in those latter islands that today they supply practically all (90 per cent or so) of the market. The Dutch tried the very refractory plant in Ceylon, but it failed. Recently the British have had good results in Penang.

The greenish or reddish unopened flower-buds are borne in clusters at the tips of slender twigs. Sun-dried for a few days, they are brown, brittle and ready for the sacks. The slightest rain on the drying buds at once blackens them. The very pungent aroma exhaled at noon from a warehouse into the narrow alleys of Zanzibar city is even stronger than pimento odors in Kingston, Jamaica.

There is probably no more difficult crop to propagate. Cuttings are useless. The fine seeds take five or six weeks to germinate, and even then they grow so slowly that it may take ten years before the first small crop appears. Some 5 to 8 pounds of dried buds are considered a fair yield for a tree. In Zanzibar, however, there are trees 25 feet high which give thrice that amount probably. Seventy to 100 trees are set to the acre. There are three or more varieties.

The crop in the twin islands of Pemba and Zanzibar is around 9,000 tons. Light ladders are required there for the larger trees. Bamboo poles are also used for beating the top branches. Hand-sorting the dried buds is done by Swahili women.

The only serious pest of the cultivated clove is an alga, *Cephaleurus mycoidea*. This is one of the very few algæ which is known to attack leaves destructively. The alga yields fortunately to bordeaux mixture, according to Ridley.[1]

Two pickings are made in the Moluccas, one in Zanzibar.

The clove trade will probably long remain largely in the hands of Zanzibar brokers.

[1] Ridley, H. N., "Spices," 1912.

United States uses some 3,500 tons of this spice a year, worth $1,250,000 to $1,500,000.

There are a dozen or more possible rivals of the clove and nutmeg, denizens of partly explored jungles of Brazil, Papua, Madagascar, and the heart of the Dark Continent. Some of these trees combine the aromas of several trade spices in their barks, fruits, and seeds and some of them will take their place among the world's food commodities. Several species of the Myristicaceæ have good-sized seeds —larger than the true nutmeg—which contain vegetable tallows with melting-points above 95° F. These hard fats are in great demand in soap manufacture, because they help save the expense of hydrogenization. The Lauraceæ are very numerous in all tropical forests, but it will take many years to work out their economic status as spice and oil trees.

PIMENTO

Allspice, *Pimenta officinalis,* is indigenous to Jamaica where it has survived five centuries of civilization. It is not indispensable, but always quoted on the market. No other country has ever grown it commercially.

Pimento or allspice is an attractive tree of the Myrtle family, 15 to 30 feet high. It is rather slow-growing, coming into flower when about eight or ten years old and attaining a 15-inch trunk when fifty years old. It prefers the limestone hills and sloping savannas of southwestern Jamaica. The ripe berries, about 1/5 of an inch in diameter, brownish-black, are devoured by several species of birds.

No cultivation is required for allspice. Grass grows under 95 per cent of the trees. The grove is thinned out for firewood and charcoal when too close together. Occasionally a straight-trunked specimen is felled for timber. The wood is tough and inclined to be cross-grained. In good pimento country the trees stand about helter-skelter, 10 to 20 to the acre. No variation is recognized, either in leaf or fruit.

In Porto Rico and the American Virgin Islands two very similar species are indigenous; the malagueta of Porto Rico has broader leaves, which are distilled for bay oil, the berries being wasted.

As to yield, however, there is considerable variation. The average crop of berries, dry, is probably under a pound; some old trees in good sites give up to 6 pounds.

A drought may upset the time schedule by several months. Normally, harvest begins in July or August and continues into October.

The picking is a crude process. The picker uses a two-pointed pole to twist off the branch tips or else he climbs the tree and breaks or chops off the branches carrying the most fruit, while a helper gathers them up and throws them onto a mat or square of canvas or gunny where they are whipped or flailed till the berries, green and brown both, are all off. The pile of branches and leaves (full of bay oil) are then tossed back around the base of the trunk as a quasi-mulch, and the berries are poured into a sack. Spread out on a coffee barbecue platform the trash is picked over by women and children. Some of the ripe berries [1] and most of the undersized are thrown aside, instead of distilling them for the oil, worth some $2.00 a pound.

The berries are sun-dried on the warm floor of the barbecue for four to eight days, raking over and over to get an even turn. The green peppercorns soon turn light, then dull brown, and the odor turns from bay to spice.

The following recommendations are useful in growing allspice: Use the leaves from the lopped-off branches for distilling; cut the branches with a tree-pruner or with a long-handled tool, such as telephone linemen use, there is no need to climb the tree, much less to break the branches by hand; not more than one-fourth or one-third of the total head of branch tips is to be removed at one picking; the so-called man trees, which seldom set fruit, should be

[1] Some are distilled to make "pimento dram," a very hot liquor—spiced rum.

removed or used only for bay oil; the interspaces in suitable ground should be filled in with seedlings, seed for which, of course, should be taken from the best trees, about 100 to 150 trees can safely stand on an acre; artificial dryers on large estates would probably prove economical, turning out a product which could be left a year if necessary, and in one day instead of a week.

CAPSICUMS

The great group of capsicums is American. The pre-Inca tribes, who built the marvelous Macchu Picchu and established the terrace system and great granaries in the central Andean region, domesticated several types of these Solanaceous herbs and shrubs, gave them special names and passed them along northward. Chili was a Nahuatl word, Mexican not South American. Now, 4,000 years or so later and 400 years after the great boom in plant introduction work started, the entire world grows these chilies, or red peppers. They hybridize readily; graftage is possible.

Some of these spice plants are really dangerous to handle, the oleo-resin in their fruits and seeds being so exceedingly pungent. Others are so mild that the entire fruit may be eaten raw.

The sun-dried, flattened, crimson fruits of the "hot" chilies are the commonest spice in many regions of Mexico, India, East Africa and Malaya. The irritant-stimulant action of these condiments is supposed to prevent tropical liver and to ward off fevers; they undoubtedly do more good than harm in the digestive tract. Habit is a strong factor in this use of capsicum: a Tamil coolie will grind up the whole very small fruits of the Bird, or Devil, pepper and eat this fiery paste on his rice in amounts that would certainly paralyze and injure the nerve plexi of the throat and mouth of anyone not accustomed thereto.

Several varieties of capsicums should be grown in the kitchen-garden of every estate in the tropics.

These spice plants are nearly immune to the terrible

bacterial blight, *Bacillus solanacearum,* which plays such havoc with tomatoes, potatoes, and eggplant, especially in the tropics of the New World. This fact being at last realized, West Indian farmers are now shipping large quantities of sweet peppers to the northern markets during the winter season.

Some 10,000 to 15,000 plants of either Sweet or Hot chili (not "Chilli") pepper may be set in an acre. With the improving types of sun-dryers, there should be no difficulty in reducing the moisture-content of the Hot pods below the mold-danger point. An acre should give inside of nine months half a ton of dried chilies, worth around $150.

CARDAMONS

The cardamons (*Elettaria Cardamomum* vars.) have for many centuries held a high place in public esteem. There is no better aroma, though to some palates it is perhaps a bit too bizarre and heavy. The smell and taste of this spice seems to belong distinctively to the Orient.

Cardamon is native to south Indian mountain slopes and is probably still to be found in the wild state. For many years only the wild seeds were exported, but now it is a regular crop in Ceylon and south India. It is a close relative of ginger in the Zingiberaceæ. Old plants in good soil may stand 10 feet high.

The capsules are borne the year around on peduncles arising from the thick rootstock. The latter sends out side-shoots, gradually forming a stool which requires breaking up after a few years. According to the variety the paper-shell fruits vary from ½ inch to thrice that length. The pods are carefully picked before ripening and dried on trays in the sun; they are usually bleached with sulfur.

Cardamon is the most expensive spice on the market. The price a pound ranges around $1.00. United States imports about 175,000 pounds a year. It is also used in medicine, a powerful carminative and stomachic.

The divided rhizomes, or crowns, are set in large hills

PLATE XXIV.—*Above:* the langsat (*Lansium domesticum*). *Below:* yautias (Xanthosoma spp.), six feet tall; the oldest Porto Rican crop; inherited from the Arawak Indians.

8 or 10 feet apart. Seeds may be sown but are delicate and slow. An acre yields only some 250 pounds of dry capsules, one of the lightest tropical crops.

TURMERIC

Turmeric (*Curcuma domestica, longa* and others) is a close relative of ginger, native to some region of tropical Asia (Cochin-China perhaps) and now naturalized in many countries. It was one of the old spices which the Europeward caravans took out of India before the Portuguese and Dutch took control of the trade.

India uses daily enormous quantities of this mawkish but colorful condiment. Some 60,000 acres are in crop there. The surplus goes to America and Europe for coloring various foodstuffs. Ceylon even imports some 450 tons from India. Formosa also cultivates it.

Grown and handled like ginger, it is, however, much lower in price. Native practices obtain in India whereby some of the raw unpleasant flavor and odor is overcome.

Turmeric, with the zedoary, galangal, and other closely related spices, is one of the principal ingredients of the famous oriental curry.

CHAPTER XXIII

MISCELLANEOUS CROPS

THERE remain a number of tropical crops not readily classified in the foregoing chapters, yet of sufficient importance to require brief record in this book. They represent a great variety of plants and utilities.

Annatto, *Bixa Orellana,* is a small tree of the Bixaceæ, native of some part of tropical America. The Caribs called it roucou and one branch used to keep their bodies painted with the seed paste, wherefore they became known as the Roucou Tribe. The Arawak name was bixa. It was long ago taken to India and Ceylon and it has become naturalized in parts of West Africa. Brazil, India, and the Antilles, particularly Porto Rico, supply the market, which absorbs hundreds of tons a year.

There is no more satisfactory tree crop so far as growth and field behavior go. The plant grows very rapidly from seed, and begins to bear the second year. It reaches 8 to 15 feet and branches heavily. The trees may be set 10 feet or 12 apart, 300 to 435 to the acre. The yield of dry seed may run from 300 to 600 pounds. The export value varies from 6 or 8 to 15 cents a pound.

The beautiful large lilac flowers are followed by spiny dry flattened capsules, 1 to 1½ inches long, and these open like small brown clam-shells exposing the mass of scarlet seeds about the size of a large tomato seed. The powdery aril of the seed comes off at a touch and may be made into a paste by putting the dry seeds into hot water and skimming off the waxy dust which rises. There used to be so much adulteration of this paste that now the wholesale buyers prefer to import the fresh seed in sacks.

United States imports several hundred tons a year, of which Porto Rico supplies some 120 tons.

Recent study in Porto Rico shows that there are at least five varieties, varying greatly in the amount of the coloring principle, arnottin, in the seed coating. The better ones are being bred up.

Annatto is a nearly tasteless coloring matter which has been used in Europe and America for a century or so to color cheese, butter, and other foodstuffs, and even for dyeing fabrics. A good part of the rice served twice a day on tropical American tables is colored red with this achiote, as Latin-Americans call it.

Gambir, *Uncaria Gambier,* is a coarse climbing shrub, of the Rubiaceæ, native of Malaya. Java and Johore have long been the foci of the crop. Rubber and coconuts are driving it back to less valuable lands. The leaves and small branches, or even chips of the wood, when boiled give a thick black or purplish semi-solid substance. When cooled and molded into solid blocks this material goes into trade as one of the cutches for dyeing and tanning, especially for khaki colors. It is also used in medicine and as a masticatory.

Cutch from the red mangrove, *Rhizophora Mangle,* of the family Rhizophoraceæ, is a staple trade commodity. The bark, especially from trees over 3 inches in diameter, is rich (around 40 per cent) in tannin. The species is common throughout both tropics, and is one of the few dicotyledons that can grow in full-strength sea-water. The bark or even leaves when boiled gives a paint-like product which may be poured into bags, barrels, or even leaf baskets when nearly cool. This black somewhat brittle resin varies considerably in value.

Divi-divi, *Libidibia* or *Cæsalpinia coriaria,* is a flat-topped fine-leaved legume tree of the Antilles and Central America. The short curved brown pods are a common source of tannin. The tree is seldom cultivated, but could well be grown on much of the waste dry land in Santo

Domingo, Cuba, Venezuela, and Brazil. A ten-foot tree may yield two or three sacks of pods; their tannin-content is around 40 per cent.

Brazil-wood, *Cæsalpinia brasiliensis* of tropical America, and *C. Sappan*, the sappan-wood of the East Indies are sister species with divi-divi. Their heartwoods are of good value in dyeing reds, purples, and browns and in making red inks. There are many false Brazils.

Logwood, *Hæmatoxylon campechianum*, is probably a native of Central America. Haiti and Santo Domingo seem to develop this legume to the greatest degree. In these two republics the peculiar corrugated or clustered trunks may attain a diameter of 2 feet and a height of 20. Jamaica and Cuba supply much of the wood. Extract plants have been installed in Jamaica, Haiti, and other localities, but, though the powerful roaring chipping machines and digesting tanks work well, the trade seems to prefer the heavy crooked logs to the purplish-black cakes of the extract. Removing the bark and thin whitish sapwood from the brownish heartwood prescribes cheap labor (Plate V).

The bomah-nut, *Wetriaria macrophylla*, of east Central Africa, is a dual-purpose tree cultivated abundantly in the upper Zambesi Valley. The almond-like seeds yield a sweet bland oil much used by the natives in cooking, like that of the mafurra of Mozambique. Though a member of the Euphorbiaceæ, the oil appears quite wholesome. The seeds are also used in tanning and are in the trade.

Fustic, *Chlorophora tinctoria*, is one of the best-known dye-woods. This denizen of "the steaming stillness of the orchid-scented glade" in tropical American forests was searched out and felled by the thousands during the Great War shortage of dyestuffs. Khaki dye went sky-high. The golden-yellow heartwood turns quite dark on exposure to the air. It is closely related to the breadfruit.

One of the most popular dyestuffs of the world is indigo. For nearly half a century the synthetic product has competed with the natural and this rivalry will long continue.

The indigos—some five cultivated species—are rapid-growing stiff-stemmed shrubby herbs of a weedy appearance. When some 4 to 6 feet in height and in flower, the stems are cut (not too low if a rattoon crop is desired) and thrown into tanks. Here the peculiar glucoside in the green parts of the plant transforms the starchy materials into indigotin during a fermenting period of half a day or so. By beating the plants from time to time, and keeping them immersed in the warm or not too cool water, the coloring matter separates out and falls to the bottom of the tank. This is churned about and allowed to settle in a second tank, then dried in blocks or cakes.

Although a genuine legume, the indigo, or añil, as it is called in Spanish America, seems to be hard on the soil and is not liked as a nitrogen-collector. It may be broadcasted or planted in rows 2 or 3 feet apart. An acre should yield 8 or 10 tons of green plants, rattoon crops less. A ton of plants yields about 30 to 50 pounds of dry paste. The residue from the tanks is seet, a first-class humus manure. In Java, whence most of the indigo now comes, the dye-plant is grown as an intercalary crop with tea; the seet seems to be an ideal organic fertilizer for the major crop.

Several other plants have indigo-like materials in their leaves; some have yellow or brown dyes. The flowers, the roots, the barks have also many colors and queer compounds.

Opium is one of the major crops. India, the original habitat of *Papaver somniferum* of the Papaveraceæ, produces around 2,000 tons of this nauseous resin; China is producing now probably five times as much. $250,000,000 would hardly purchase the 10,000 to 15,000 tons or more, the wholesale value running around $20,000 to $30,000 a ton.

There are two botanical varieties of the opium poppy: the *glabra* is grown mostly for the medical drug market, while the *alba* furnishes most of the "dope" for smoking

and eating. It seems hardly credible that the per capita consumption of morphine drugs in United States is now around 36 grains a year, one-third of which amount is really necessary.

The farmer scratches four or five times each young capsule on each of the several thousand plants in the acre of carefully weeded land, and receives from 20 to 45 cents an ounce if he has not adulterated too much the blocks of gum (collected every morning from the previous afternoon's cuts). An acre yields only a few pounds. One ounce should give about seventy smokes at around 5 cents each.

The Hindu farmer gathers the ripe capsules and shells them for the minute seeds. These are exported to Europe for their oil or some may be used locally for food, with no great danger. The fresh leaves may be used for pig feed. The stalks are the farmer's fuel.

In China, at least, opium is a regrettable crop. It is much more injurious than hashish. The opium habit is a grave factor in oriental economics. The United Kingdom is said to receive some $17,000,000 annually in opium revenue taxes.

The castor plant, *Ricinus communis*, is a coarse-branched shrubby herb of the Euphorbia family. There are many varieties, usually from 6 to 30 feet high. Some have purplish leaves, and nearly all have a glaucous bloom on the stem and leaves. It is probably a native of tropical Africa.

Castor resents crop systems. Allowed to stand in a weedy fence-row it is happy; planted out, say 4 by 6 or 8 feet apart and carefully tended, it does not thrive. Ten to 20 bushels of cleaned seed are a fair acre yield. The globular capsules, covered with soft pines, are threshed by placing them in the sun on a barbecue or firm surface; the heat causes the woody fruits to burst open, throwing the seeds some little distance.

The beautifully mottled seeds contain a poisonous alka-

loid, ricin. This stays in the cake if the pressing is well done, which is therefore very poisonous for live-stock, even pigeons and honey-bees being killed by drinking water in which a small quantity of the pomace cake is dissolved. The oil, which runs 30 to 45 per cent in good varieties, is a valuable trade commodity. United States imports anywhere from 5,000 to 50,000 tons of the seed annually.

India, Brazil, Malaya, China, Mexico, Ceylon, even southern Europe and central United States produce the bulk of the crop, which may run to over 200,000 tons. In 1913 India exported 150,000 tons of castor seeds.

One of the most obscure of the great oil crops of the tropics is safflower or kurdi, *Carthamus tinctorius,* of India. There are probably 1,000,000 acres planted in this Composite crop, mostly in the Bombay Presidency. The flowers are extensively used in dyeing and in the manufacture of toilet rouges; they contain a bright yellow and a dark red (carthamin) dye. The seeds contain about 25 per cent of a pale yellow edible oil which is also in international trade. The leaves are used as a salad vegetable. Its cultivation is extending into Egypt, Nyasaland, and even into Spain.

Citronella oil is one of the most widely dispersed commodities in the world. The lush stools of this grass, *Cymbopogon Narus,* 4 to 5 feet high and a yard in diameter, cover scores of thousands of acres in Java and Ceylon. Two to four cuttings are obtained each season for several years. A ton of the long fragrant leaves yields about 4 pounds of oil by distillation; an acre should yield 10 or 12 tons. This oil is worth from $1 to $2 a pound. United States imports some 1,320,000 pounds.

Lemon-grass, *Cymbopogon citratus,* is a sister species which yields a much more valuable oil, though less of it. There are over a dozen species of these oil grasses in the Middle and Far East and all could be bred up very profitably; in fact, this work has been started at the Buitenzorg Experiment Station. The odor of these grass oils ranges all the way from an overpowering effluvium to a delicate

geranium-like perfume; some are medicinal and most are used in the perfume and soap industries.

A similar grass, vetiver or khus-khus, *Anatherum* (*Vetiveria*) *zizanoides*, has leaves without odor but the roots are saturated with a sandal-wood-like oil worth some $10 a pound as a fixer, or holder, of the volatile essences. In the West Indies this Indian grass is wrongly known as patchouli. The true patchouly is a rare mint, *Pogostemon Cablin*, native of the Philippines and now cultivated in Java, Ceylon, India, and especially about Singapore, where with expert attention some 10 to 18 hundredweight of leaves and branches are produced on an acre. Patchouly is a difficult crop to propagate and handle but the oil (some 20 pounds to the acre) is worth $5 to $8 a pound.

All the world knows the bay, at least by its refreshing smell. It is not generally known, however, that it occurs from Mexico to Surinam and that its only large solid stand is on the island of St. Jan, two miles to the east of St. Thomas, of the American Virgin Islands. Here there are several square miles of forest composed almost entirely of this malagueta, ausú, or bay, *Pimenta acris* (*Amomis caryophyllata*) of the Myrtle family. According to Britton and Wilson, this dark-leaved tree "species consists of many races" scattered through Cuba, Santo Domingo, Porto Rico (where it is semi-cultivated), both American and British Virgin Islands on to Trinidad. The thick fragrant leaves and small branches slashed off by one man up in the tree and stuffed into sacks by another on the ground, are taken down to the stills. Several hundredweight of leaves go into the kettle at a cooking, the steam and pungent oil being condensed in a "worm" in a tank of water and then separated in a large Florence flask. The volatile green (or, in inferior grades, yellowish) oil is worth from $1 to $2 a pound. An acre of bush should yield 1 to 1½ tons of leaf in two or three slashings. The oil outturn may run from 25 to 75 pounds. Bay does not behave well in cultivation.

A rather obscure but widely grown and very old crop is

the ben or murunga, *Moringa oleifera.* It will probably expand greatly, because very recently it has been found, by the Porto Rico Department of Agriculture and Labor in 1926, to be a good forage plant. The very rapid-growing tree is one of three species comprising the Moringa family; it is probably Indian in origin. It reaches a height of 20 feet or more, but begins to bear in the second year. The clusters of white flowers are followed by long slender three-angled pods which are eaten like string-beans. The round seeds contain an oil resembling that of the olive, though somewhat bitter; 40 per cent of it is a white solid fat. The liquid oil is used in the enfleurage process of perfume manufacture. The roots are pungent and when young, edible, whence the name in some places, horse-radish-tree. The lush foliage is much relished by pigs and cattle. How long the tree will endure browsing or clipping is not known.

In the Cagayan Valley of northeastern Luzon, there is a large variety, grown for human food, called malungay. The immature pods, 15 to 20 inches long, are brought to market in large bundles. The flowers are also eaten as a salad. This potentially highly important crop is practically unknown outside of India, Syria, Nigeria, and Jamaica.[1]

[1] In 1904 "The Plant World" published "A More or Less Moralless Fable" by the author; in it a plant explorer after great difficulties succeeds in introducing a new food crop, only to be told by the people, "The food of our fathers filleth us fully: for the feed of barbarians we hanker not yet."

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